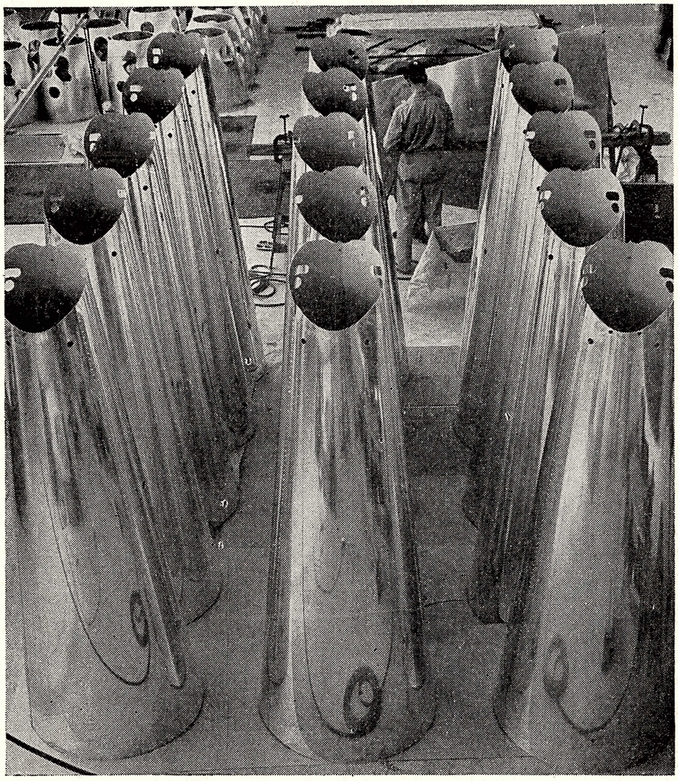
CHAPTER XIV

SUBASSEMBLIES

"Subassembly" means the putting together of one or more fabricated parts into a unit. Inspectors should give great care and attention to the process of actively checking and inspecting subassemblies submitted by production. Smaller units are built up to facilitate manufacture, inspection, and possible



A group of completed tail cones awaiting installation. (*Courtesy of Ryan Aeronautical Co.*)

rework or replacement. Therefore, thorough and diligent inspection is necessary, for any rework or replacement later on will prove costly.

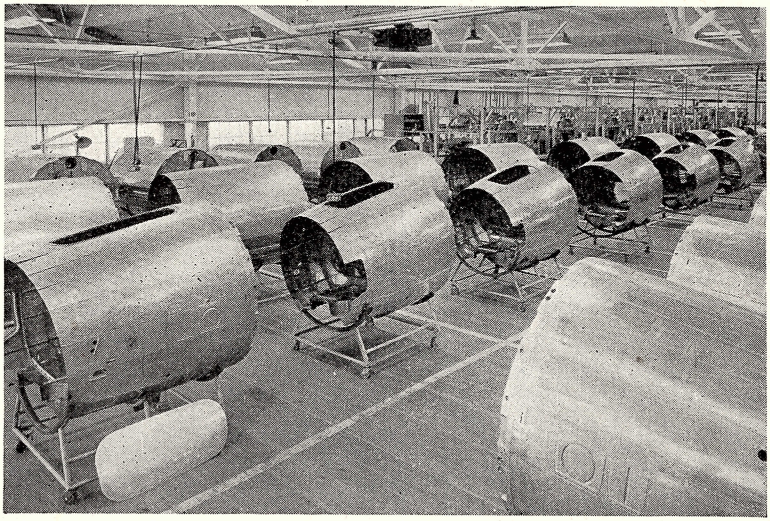
14.1. The "Technical" Check. Actual inspection of subassemblies should not be attempted until the inspector has become thoroughly familiar with all requirements, as shown on the blueprint covering the subassembly awaiting his inspection. Knowledge of authorized finish and process specifications applicable to the work on hand is required for successful and dependable inspection.

It is suggested that work submitted for inspection should first be inspected for compliance with blueprint requirements; the physical checking for workmanship and other requirements should then follow.

This checking with blueprint requirements is what is known as the "technical" check; it should be accomplished carefully and methodically.

14.2. Studying the Blueprint. The first thing to read on a blueprint is the number and the description of the article represented. Next, a check is made of the model affected, the latest drawing change letter or number, and the next assembly listed. It also should be noted which set of specifications on finishes is applicable. To continue, the contents of the Material Block and the "general notes" are read, and locations of individual parts are established. The various changes incorporated on the blueprint are carefully noted. Close attention should be paid to data near or in views and sections on types of rivet, bolts, spacing of rivets, edge distances, special cutout, etc. Close attention should be given the location of laps and skin joints, doublers, openings, cutouts, and material requiring heat-treatment before use on the assembly. Special methods of locking and installing safety wire may be shown, and the material called for is important. Information and requirements regarding waterproofing, etc., are important. Thorough familiarity with requirements and a clear mental picture of what the blueprint represents are necessary if the inspection of a subassembly submitted by production is to be successfully conducted.

14.3. Checking to Blueprint. Checking of the article to blueprint is next in order. Unless one is extremely well acquainted with the work being inspected, the check for workmanship should not be attempted yet. The same routine as that applied to reading the blueprint is repeated in checking the physical article to make certain that all parts are accounted for, that their location is correct, and that cutouts and their sizes and shapes are according to blueprint. No check should be hurried, for an oversight can occur very easily.



Engine nacelle subassemblies at the Northrop factory. *(Courtesy of Northrop Aircraft.)*

When the article is acceptable as far as compliance with blueprint requirements is concerned, the check for workmanship is begun.

14.4. Workmanship in Subassemblies. Workmanship is the care and attention given the "building" of parts into an assembly. Compliance with accepted standards, appearance, and uniformity are primary factors to be noted by inspectors. Work should not be considered as being "good enough" but should be either acceptable or not acceptable. Safety in aircraft should not be compromised.

14.5. Unsatisfactory Subassemblies. Noncompliance with technical requirements or standards of workmanship may be judged on the basis of the conditions enumerated below. These may be considered sufficient reason for not accepting the work submitted for inspection.

1. Drawing requirements not followed.
2. Parts used not up to the latest change.
3. Omission of protective finish required by finish specifications, such as anodic, plating, or paint.
4. Finish specifications not complied with, affecting the attachment of dissimilar metals.
5. Substitution of materials without proper authorization.
6. Repairs made without proper authorization.
7. Bonding requirements not followed.
8. Material:
    - *a.* Soft.
    - *b.* Incorrect type.
    - *c.* Incorrect thickness.
    - *d.* Incorrect or no protective finish.
    - *e.* Cracked or otherwise damaged.
    - *f.* No relief radii in cutouts or bends.
    - *g.* Sharp edges or burrs left on material.
    - *h.* Oversize or elongated holes.
    - *i.* Excessive amount of unused holes, due to misdrilling or not coordinating parts.
9. Rivets:
    - *a.* Wrong size.
    - *b.* Incorrect type.
    - *c.* Points too high or too flat.
    - *d.* Countersunk too deep.
    - *e.* Countersunk too little.
    - *f.* Heads damaged.
10. Bolts:
    - *a.* Incorrect type.
    - *b.* Too long.
    - *c.* Too short (important in shear locations).
    - *d.* Heads damaged by wrenches of poor fit.
    - *e.* Damaged or stripped threads.
    - *f.* Ends filed or cut off.
11. Castle or shear nuts:
    - *a.* Damaged by wrenches.
    - *b.* Damaged or stripped threads.
    - *c.* Filed to fit on installation.

12. Stop nuts:
    - *a.* Used with bolt drilled for cotter pin.
    - *b.* Tapped out with thread tool.
    - *c.* Used with thread lubricant.
    - *d.* Damaged or stripped threads.
    - *e.* Filed to fit on installation.
13. Nut plates:
    - *a.* Damaged or stripped threads.
    - *b.* Tapped out to oversize.
    - *c.* Cracked near rivet attachments.
    - *d.* Filed to fit on installation.
    - *e.* Thread lubricant used.
    - *f.* Used where exposed to temperatures for which they were not manufactured.
14. Washers:
    - *a.* Filed to fit on installation.
    - *b.* Improper or no finish.
    - *c.* Too large for bolt used.
15. Screws:
    - *a.* Damaged slot in head.
    - *b.* Damaged or stripped threads.
    - *c.* Incorrect type.
    - *d.* Ends filed or cut off.
16. Other unsatisfactory conditions:
    - *a.* Insufficient edge distance.
    - *b.* Flanges riding joggles.
    - *c.* Parts riding on radii of other parts.
    - *d.* Insufficient or no clearance between units.
    - *e.* Over- or undersize rivets or bolts.
    - *f.* Damage by drills, rivet guns, or other causes.
    - *g.* Cotter pins poorly installed or omitted.
    - *h.* Wrong type of cotter-pin material.
    - *i.* Shavings or other foreign material between surfaces.
    - *j.* Flanges of castings cracked.
    - *k.* Oversize or too many washers used on bolt installations.
    - *l.* Heads of bolts, washers, or nuts not seating properly.
    - *m.* Heads of bolts or nuts damaged by poorly fitting wrenches.
    - *n.* Bearings binding poorly spun in or staked.
    - *o.* Method and material of installing safety wire not complying with blueprint requirements.

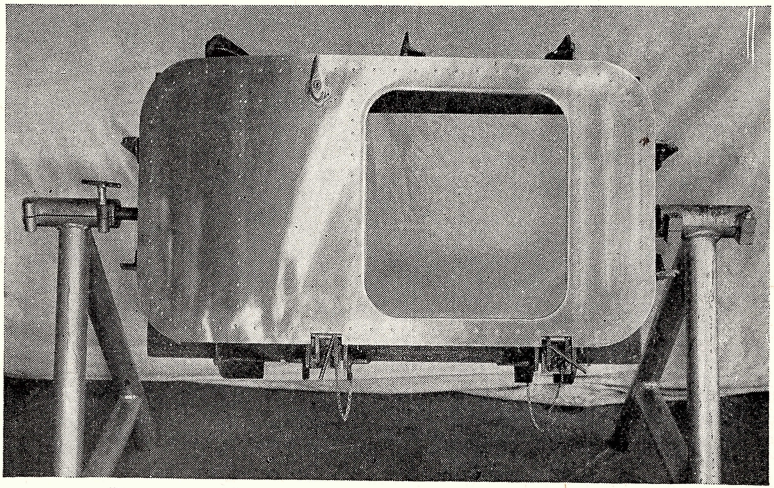
p. Lubricant specifications not complied with if subassembly is subject to these on some of its details.

14.6. Authorization Required for Correction. When in doubt about any of the conditions listed above, the inspector should consult a duly authorized person. Some of the conditions mentioned require specially authorized instructions for correction.

CHAPTER XV

MINOR ASSEMBLIES

15.1. Preliminary Inspection of Doors, Hatches, Etc. Doors and hatches are very important to the safety of the airplane, particularly if they are outside doors. As a unit, they should comply with all technical or blueprint requirements, as well as with finish specifications and standards of workmanship.



Door assembly in its jig. (*Courtesy of Douglas Aircraft.*)

Generally, details such as doors receive two inspections, *viz.*, a preliminary and a final inspection. Preliminary inspection is conducted while the door is in its tooling jig. A jig is used in construction for the purpose of facilitating building, to ensure fit and interchangeability, to secure the correct contour or outline, and to hold the alignment of the attaching hinges and locking mechanism. Inspectors check these items while the door is in its jig.

15.2. Areas Subject to Closeup. Should a door be designed so that upon completion its interior is inaccessible to inspection, it is most important that inspectors check and inspect the interior before it is closed up. In such a case the inspector checks for compliance with blueprint requirements and standards of workmanship. In addition, inspectors check:

1. The condition and safety of hinge attachments.
2. The locking mechanism for operation and safety. The operation should be smooth and should not require unusual physical effort. Clearances are observed through the entire operating range, and particular attention is paid any possible overtravel or binding of any part of the mechanism. Blueprint information on methods of installing safety wire is important, and compliance with it is essential. Provisions for emergency release of the door are closely inspected, for their smooth and efficient operation is essential.
3. Familiarity with specifications applicable to the model of which the door is a part is necessary. In a case such as is under discussion, specifications may call for lubrication of certain parts of the door mechanism, weatherproofing, or paint application.

Any cutouts made during assembly should be to dimensions; sharp or rough edges should be smooth and free from cracks. Should the door be designed with a window, it is important that the crimped flange be closely inspected for possible cracks and that the flange be trimmed evenly along its entire length.

15.3. Inspection of Door after Removal from Jig. After the door assembly has been removed from its jig, its interior is inspected before it is painted. In aircraft, all closed areas are painted prior to being closed up, as a protection against the elements. After painting a visual inspection is given the interior to make certain that no bearing surfaces or cables of the door mechanism have been covered with paint.

15.4. Final Inspection. When the door assembly is submitted for final acceptance, it is visually inspected for appearance and standards of workmanship, operation of the door mechanism, correct technical details, and compliance with finish specifications. Should the blueprint call for identification of parts, such as "Exit," it is important that the manner of such identification be according to the blueprint. Particular attention should be paid to the trim and edge distance of the door cover, which is important on outside doors.

15.5. Doors Used in Interior Installations. If the door is designed to be used in the interior, soundproofing may be required. Inspectors should inspect such doors for tightness of cover, the manner of installing soundproofing and the operation of the door-operating mechanism and should specially check the over-all dimensions as given on the blueprint.

15.6. Doors Consisting of Hinged Parts. Another type of door may consist of two parts hinged together. All the points enumerated in the discussion above apply to this type. In addition, such doors should be inspected for operation of the "folding" action, safety of hinge arrangement, clearance between the halves during the folding of the door assembly, and weather or sealing provisions. Bonding provisions if required are checked for compliance with factory specifications.

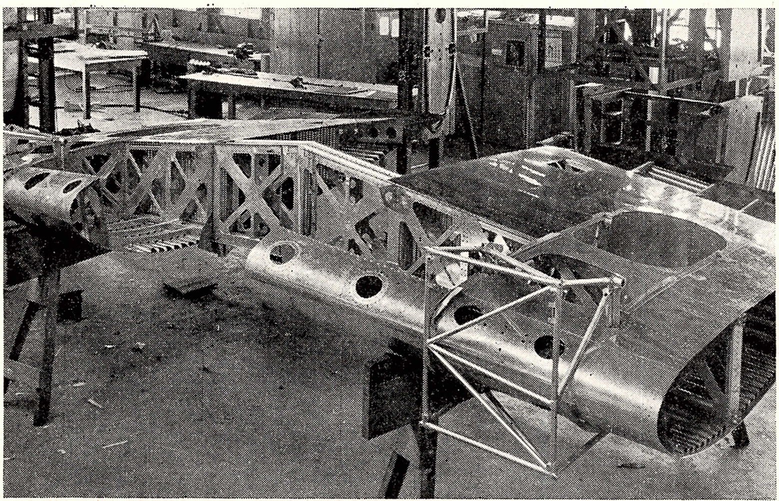
15.7. Seats. Inspectors check seats for compliance with blueprint requirement and standards of workmanship. Close attention is given the condition and functioning of the adjusting mechanism and its lubrication requirements. Safety-belt attachments are inspected for security of attachment and condition of the fittings. Finish specifications are checked with respect to any information plates or stencils required. Should any upholstery be provided, it is inspected for condition, appearance, and manner of attachment.

15.8. Floors. Workmanship is of great importance here. Rivets are checked, particularly in sections difficult to rivet. Corners and flanges are inspected for fit at joints and for cracks. Over-all dimensions are important and are to check within dimensions and tolerances given on the blueprint. Attachments for installing removable floors are inspected; their correct location is important. Compliance with paint specifications should be noted.

The dependability of flooring is important, and floor subassemblies require close and careful attention to all details. It is essential that they comply with requirements regarding type or kind of material used, manner of assembly, and dimensions.

15.9. Fixed Vertical and Horizontal Stabilizers. These units are attached to the fuselage tail section and are a part of the empennage of the airplane. On their aft side are provisions for attaching the rudder and elevators. Stabilizers are considered in the class of "primary" structures. The task of inspecting them is therefore a responsible one, and frequent reference to blueprint information is advised. The process of inspection is simplified by the advanced method of their construction and the extensive use of highly developed tooling. However, present-day production demands the constant and undivided attention of the inspectors.

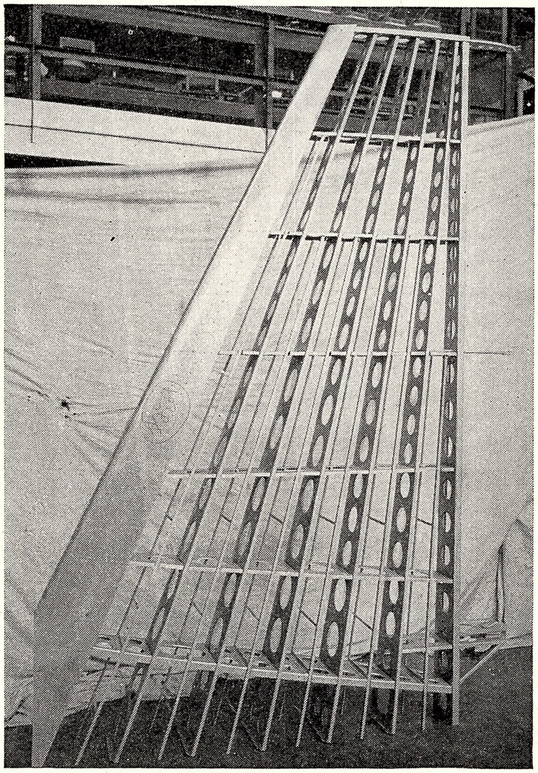
15.10. Structure of Stabilizers. During structural setup, inspectors can readily inspect stabilizers for alignment, clearances, fittings, attachments, and rivet and boltholes. Flanges of ribs and their tabs are checked closely for cracks or preloads where angle stringers are attached. The stringers are inspected for rivet hole edge distances and the general appearance of rivet lines. These should be not wavy but straight and should have uniform edge distances.



Center section of Lockheed Electra. (*Courtesy of Lockheed Aircraft.*)

15.11. Fitting Skin Sheets. In fitting skins, it is important that trim lines be straight, the surface of the skin material not damaged, and the area being drilled adequately supported from behind to prevent holes being drilled poorly. Close attention is given to skins after they have been fitted. All rivet holes must be freed of all fine burrs before any further operations are begun, such as counterpunching. This is important, for these fine burrs may become embedded in the metal or may cause fine cracks in the metal when the pressure of the counterpunching is applied. Inspectors should also check the gage of the skins, their location on the structure, laps and joints, and rivet spacing. These must conform to blueprint requirements.

15.12. Final Inspection of Skin Sheets. Before skin covering is installed on its structure, inspectors check it for general appearance, such as lack of surface damage and trim lines straight, or even, giving a uniform edge distance and within authorized tolerances. Material adjacent to countersunk areas is subjected to close inspection, the main object being to discover any cracks that may have formed. Whenever the slightest doubt exists in the inspector's mind as to acceptance or refusal, he should contact his superior. When the skins have been found satisfactory in all respects, they are ready for final installation.



Structure of vertical stabilizer before installation of skin cover. Note alignment on nose section. (*Courtesy of Douglas Aircraft.*)

15.13. Installations in Stabilizers. Any installations such as conduits or small electric junction boxes for formation lights, if called for, are installed and inspected for compliance with blueprint requirements and standards of workmanship and checked for compliance with bonding specifications. Any waterproofing provisions are closely checked. These are usually in the vicinity of light receptacles; or if the vertical stabilizer is designed for installation of a Pitot head, the provisions for this and their waterproofing are closely checked for compliance with all requirements.

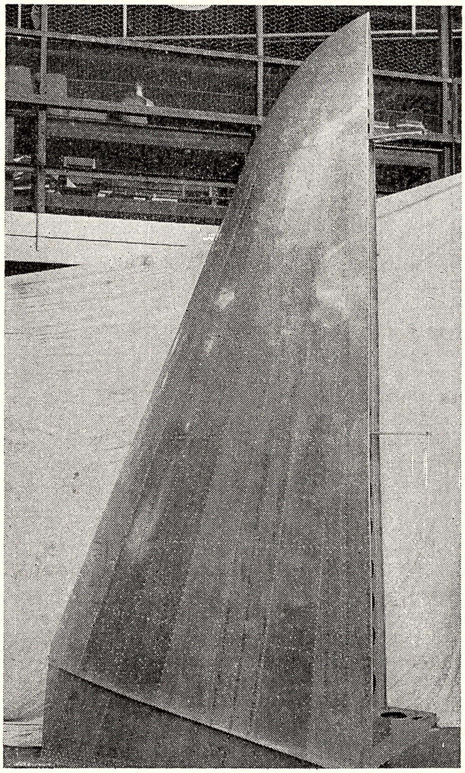
15.14. The Structure Prior to Skin Installation. Before skins are attached to the structure, it is important that the structure be prepared in all respects. This requirement includes clean lines, particularly where skins will be fastened. An application of paint may be specified, and in such cases it is particularly important that the structure be clean and free from any dirt, shavings, etc.

15.15. Inspection during Skin Installation. When the structure has been properly prepared, the skins are installed. This process is inspected periodically, particularly with reference to the riveting. During this inspection, unsatisfactory rivets can be replaced readily, which would not be the case if the skins were attached completely and then inspected.

15.16. Inspection during Closeup. As the closeup proceeds, paint specifications are followed closely. Inspectors check before painting for cleanliness of the interior and for any loose articles left inside, such as bucking bars or tools.

15.17. Attaching Provisions. It is very important that attaching provisions for rudder and elevators be closely inspected for safety and for correct alignment. In cases where hinge brackets are installed while the article is still in its jig, inspectors check the tightness of jig pins in such brackets. When any question arises as to the tightness of such pins, the inspector should consult his immediate superior.

15.18. Final Inspection of Fixed Vertical and Horizontal Stabilizers. When the unit is completed, it is removed from its jig carefully. Inspectors check the unit visually for general condition. Its nose section, or leading edge, is checked for straightness. Because it is part of an airfoil, its contour should be smooth and uniform in all respects. No flat spots or bulges between ribs or dents in the leading edge should be accepted. When these are present, the opinion of an authorized person is required before any action is taken. The skins should be tight, free from "oilcans," and neatly trimmed wherever called for. Bolt holes should not be marred or damaged from tooling pins or jig-attaching methods. Threads in holes or other parts should not be damaged and should be free of paint. Cutouts for lights should conform to required contours and are not to be cracked or otherwise damaged. The weatherproofing should conform to requirements, and excessive clearance should not exist between cutout and light-base installation. Provisions for antenna or Pitot-head installations should conform to all technical and specification requirements, as well as to standards of workmanship. It is good practice to check the condition of rudder and



Vertical stabilizer after installation of skin cover. (*Courtesy of Douglas Aircraft.*)

elevator hinge brackets. In these parts, security of installation and their alignment to each other are very important.

Safety is of primary importance in stabilizers; it is ensured when the finished product complies with blueprint data, finish specifications, and standards of workmanship. When stabilizers are found satisfactory with respect to these requirements, the inspector accepts them.

15.19. The Rudder. The structural inspection of the rudder is similar to that described for fixed vertical and horizontal stabilizers. However, certain differences exist, due to its design and purpose. The rudder may have metal or cloth as its outside cover.

15.20. Inspection of Rudder Structure Prior to Application of Interior Protective Paint. Before cloth covering is begun the structure is inspected for the following:

1. The condition, safety, and workmanship of the rudder torque tube and its installation on the rudder structure must be satisfactory.
2. The alignment, or straightness, of ribs and their installation must be satisfactory.
3. The trailing edge must be checked for straightness and possible damage, such as nicks or dents.
4. Provisions for fabric attachment must be inspected for condition and paint protection.
5. The entire structure must be checked for sharp edges or points which may snag, cut, or tear the fabric.
6. On balanced surfaces, it is important that balancing provisions conform to all requirements and be finished as called for in the finish specifications.
7. The nose, or leading-edge section, of a rudder is usually made of metal; since this section represents part of an airfoil shape, it is inspected for straightness, smoothness, and uniform contour. Its attachment to the structure is checked closely.

When the entire rudder structure is found to comply with all technical data shown on the blueprint, specifications, and standards of workmanship, the structure is accepted and is ready to receive its protective paint. Before actual painting is begun, certain precautions are taken to prevent paint from entering points enumerated in the authorized finish and process specifications, such as threads in parts, bearings, or bearing surfaces.

15.21. Inspection of Rudder Structure after Painting. It is unnecessary to describe here the process of painting, for factory specifications explain in detail requirements for the kind and uses of paints. Inspectors check the structure after painting for thorough covering by paint of all parts of the structure that require painting and check threaded parts, bearings, or bearing surfaces to see that they are free of paint.

15.22. Installation of Cloth Covering. The type and kind of material used and the manner of applying such material as cloth, tapes, and cords are covered by specification and process bulletins and are therefore not discussed here. Complete familiarity with and knowledge of these specifications and process bulletins are essential to good inspection.

15.23. Inspection of Covered Surfaces before Application of Dope. The inspector should

1. Check for compliance with all authorized requirements.
2. Note the correct number and check the installation of drainhole grommets.
3. Check the leading edge for warping.
4. Check the trailing edge for warping.
5. Check for excessive humping or gathering at cutouts, pockets, and corners.
6. Note the manner of installation and the direction of finishing tapes.
7. Note whether or not rib stitching, sewing, and fabric are acceptable.
8. Check and note what kind of dope is to be used according to the specifications.
9. Check the bonding requirements to factory specifications.

When the rudder is found in order and acceptable, the application of the dope is authorized by inspectors.

15.24. Dope-covered Surfaces. The process of dope application on cloth-covered surfaces is described in factory specifications, with which inspectors are required to be familiar.

Dope-covered surfaces are inspected for surface texture, with respect to such conditions as marred or starved places, excess scars, roughness, pinholes, sanding cuts, or blushing. Inspectors check for correct dope record, stenciling, identification of covers, color scheme, etc. The leading and trailing edges are inspected for warped condition. It is the duty of inspectors to check as prescribed humidity and temperature readings and to record these.

After thorough inspection the rudder, if found acceptable, is passed by the inspector and is identified as passed in the manner prescribed by the factory and is then delivered to the final installation department.

15.25. Ailerons and Elevators. The preceding discussion on inspection of the rudder applies also to ailerons and elevators.

15.26. Wing Landing Flaps. There are several types of wing landing flap, depending on the design of the airplane. The following paragraphs treat, not the specific type, but the subject in general.

15.27. Inspection of Wing Landing Flaps in Jig. During the building of these units, inspectors check the structure while in its jig. Attention is paid to the alignment of the structure and to the fit against the end or contour jig stops. Location, condition, and technical points of flap-attaching and -actuating arrangements are checked for compliance with the blueprint. Fittings are inspected for the manner of seating on surfaces and their alignment with other parts, as well as their attachments. Coordinated fitting of all parts is important, to exclude any possible preloads due to twisting, bending, etc. The clearances between stringers and ribs or hat sections are to be as shown on the blueprint or according to other authorized information. The entire structure is to comply with the blueprint and with accepted aircraft standards. If the structure and its cover are to be joined by rivets, the structure is painted after inspection has accepted it. Should the structure and cover be joined by electric spot welding, paint is omitted on all parts until the completion of all spot-welding operations.

15.28. Inspection before Closeup. Should the flap be of the closed type, it is necessary that inspectors check its interior prior to complete closeup for cleanliness and freedom from loose material such as shavings or tools. Particular attention is given to "blind" sections where riveting had to be accomplished. Built-in arrangements for the attachment and operation of flaps are inspected for condition and safety. Reference to blueprint and finish specifications is suggested during inspection of areas that are inaccessible after completion.

15.29. Final Inspection of Wing Landing Flaps. Upon completion of a unit, it is inspected as follows:

1. The appearance of the cover is checked. Its surfaces should be tight, smooth, and free from any damage such as scratches, nicks, and dents. The cover is checked for loose areas between ribs or channels known as "oilcans." Trim and contour lines are to conform to required standards, and edge distances should be even and as called for on the blueprint. Rivet or spot welds should be correctly spaced and should conform to all requirements and aircraft standards. Finishes, if required, should thoroughly cover the parts affected. Actual over-all dimensions are checked against those given on the blueprint. Any angular settings should be within tolerances to ensure proper fit and necessary clearances upon installation.
2. Where any access or inspection holes are provided, inspectors check the condition of the interior of the closed flap body. Provisions for the attachment of covers for such openings are to be according to the blueprint. They should be checked for safety of installation and for standards of workmanship. Generally, doublers are installed around these openings, and inspectors check for compliance with blueprint data. Doors or plates used to cover access or inspection openings are inspected for fit and required clearances, as well as for the coordination of the fastening installations. Inspectors should not overlook bonding requirements, if called for in the factory specifications.

15.30. Conclusion. The methods of inspection described in the foregoing paragraphs should not be considered the only way of inspecting minor assemblies. The importance of compliance with authorized factory data, such as blueprints, finish and process specifications, and shop-practice bulletins, cannot be stressed too highly. Inspection methods or procedures may vary owing to design requirements or factory-established systems and regulations. The foregoing description gives only a cross section of the many and varied types of subassembly. However, it is generally applicable as a basis for inspecting minor assemblies. It is suggested that inspectors consider the information contained in this chapter as a guide, not as a rule.

CHAPTER XVI

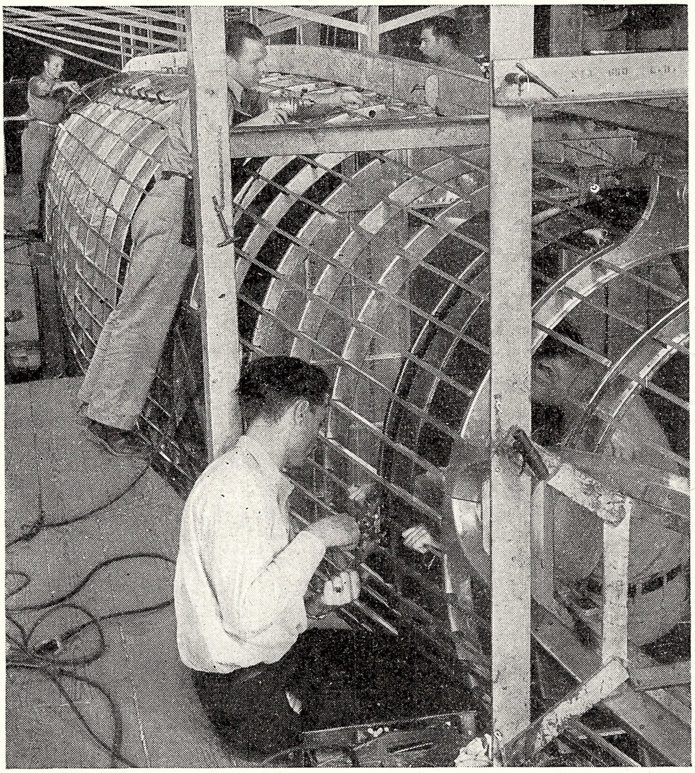
MAJOR ASSEMBLIES

The responsibility of the inspector increases with the size and complexity of articles to be inspected. To carry out this responsibility successfully the inspector is required to be familiar not only with assembly and installation blueprints but also with specifications, processes, authorized shop practices, and accepted aircraft standards of workmanship. The following discussion does not concern itself with the technical aspects of design or procedure but is a general one. It is offered as a guide, not as a hard-and-fast rule. Engineering and other authorized factory data must at all times be considered the authority.

16.1. Fuselages under Construction. To facilitate the construction of fuselages and to ensure their uniformity and conformity to design, the use of jigs is extensive. A main-fuselage assembly jig is used, which has as component parts other smaller jigs and fixtures. All jigs used are designed and built for specific purposes and are expensive. It is therefore important how such tooling is used (see Chap. XII). The construction of fuselages generally is accomplished in two distinctly different main operations, *viz.*, the "building" of the fuselage structure and the "covering" or "plating" of this structure.

16.2. Inspection of Fuselage Structure. As the frames and longitudinal stringers are placed in designed and prepared jig locations and held there in the desired position, inspectors check on the position of frames with respect to direction, the alignment of frame flanges and longitudinal stringers, correctness and uniformity of contour, and proper fit of parts. Clearances between cutouts in frames and longitudinal stringers are observed, and also the position of frame tabs in relation to the stringers. It is important that safe clearance exist between frames and stringers where these pass through, in order to eliminate the danger of damage to the frame material (see Chap. XIII).

16.3. Contour. It is very important that perfect surface contour alignment be obtained before any riveting is accomplished. Should it become necessary to rework certain locations to obtain contour alignment, such rework should be attempted only after authorization has been obtained and should be accomplished by experienced and trained men only. Rework must be carried out with care to prevent distorting, cracking, or "fatiguing" the material. Parts or assemblies should not be forced into place in order to obtain required alignment, for this will cause a "preloaded" condition with its inherent danger of failure. The same danger exists where parts that require clearance are permitted to touch each other, especially in places where pressure or movement may develop.



Fuselage under construction in its jig. Note man with rivet squeezer. His teammate holds longitudinal stringer in alignment. (*Courtesy of Douglas Aircraft.*)

16.4. Inspection of Various Parts. It is important that splices comply to blueprint requirements with respect to type, material, location, and means of fastening. Interior structural installations such as floor structures, reinforcing channels, window frames, and door jambs should fit in their respective locations, and the joining of these to other parts of the structure is checked to the blueprint. Fittings are of great importance; their installations should be checked closely to the blueprint. Oversize, elongated, or otherwise damaged holes in fittings do not conform to good aircraft standards, and inspectors should correct such cases in the prescribed manner. Edge distances on flanges of fittings or castings should receive close attention. When bolts are used to install fittings or castings, the blueprint is the authority. It should be ascertained whether or not special information is given on the blueprint as to the kind of fit such bolts are to have. This is very important, particularly where great loads or stresses are expected. Where castings are riveted to the structure, they should be carefully inspected for possible cracks caused by misalignment of the flange or excessive riveting pressure. Bolted installations must be checked for safety.

16.5. Flooring-support Installations. Alignment of flooring-support structures and their correct elevation is important. Installations for floor attachments are checked for compliance with the blueprint. Flanges should be checked for damage by ill-fitting or incorrect use of temporary floors. The flanges should not be bent, twisted, or otherwise damaged. Their condition and location are important, for the installations for floor attachment are to coordinate or match those provided on the actual floors.

16.6. Nut Plates. Where nut plates are used, inspectors should check their location, type, etc., with the blueprint requirements. The condition of the threads is important, and where the nut plates are attached they should be closely inspected for cracked material near the rivets.

16.7. Rivets. During the inspection of structures, close attention should be given to rivets. It is necessary that inspectors check type, size, number, spacing, location, and edge distances of rivets for compliance with blueprint requirements. Particular attention should be given areas that are difficult to rivet, such as remote or "blind" sections. Standards of workmanship should be acceptable.

16.8. Inspection of Structure for Damage. The material of the structure should not be damaged by drills, rivet guns, bucking bars, rivet squeezers, and so forth. When in doubt about any damage, the inspector should consult his superior.

16.9. Foreign Material. Shavings or other foreign material should not be left between faying surfaces. Inspectors should note any such condition during inspection of work submitted.

16.10. Inspection before Closeup. Areas that are inaccessible after completion are inspected for compliance with blueprint requirements, standards of workmanship, and safety. They are to be clean and free of loose material, such as screws, nuts, bolts, tools, or shavings. After acceptance of such areas by inspectors, they are finished according to factory finish specifications prior to final closeup.

16.11. Safety Provisions. Wherever a safety provision is required, inspectors are to refer to the blueprint for information. In addition the condition of such safety provisions is checked for compliance with authorized shop practices and standards of workmanship.

16.12. Coordination of Tooling and Structure. Where tooling pins are employed to hold important points, it is important that structure and tooling coordinate and matching surfaces fit each other. Inspectors should note the use of smaller jigs and fixtures. These should fit in their designed positions and should be installed at the correct time. It is improper to install such tooling later than required or to force it into position.

16.13. Final Inspection of Fuselage Structure. When a structure is submitted for inspection, it is checked and inspected according to the type of structure and individual factory procedure. Upon conclusion of inspection the necessary records are filed and depending on factory finish specifications the structure may be painted prior to application of the covering or plating. If a paint coat is specified, it is important that the entire structure be clean and free of foreign material before painting.

16.14. Fuselage Skin or Cover of Structure. The skin, or cover, of a fuselage and its installation are of vital importance, and compliance with requirements as shown on the blueprint is essential. It is therefore recommended that inspectors become familiar with such requirements and refer frequently to the blueprint. The great amount of data involved should not be entrusted to the memory. Constant attention should be given special engineering information when issued, such as changes or special orders. Finish and process specifications should be well known to those entrusted with the inspection of the plating of a fuselage, and authorized factory shop practices and aircraft standards of workmanship should be familiar to them. Whenever questions arise as to correction of production errors, the inspector should follow established factory procedures and when in doubt should consult his superior.

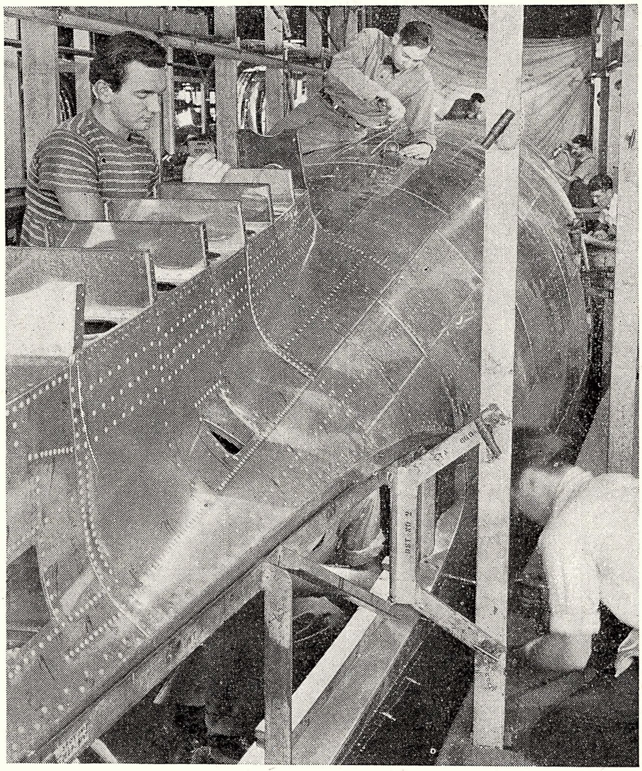
16.15. Material for Skin. The material used to cover a structure and its compliance with blueprint requirements, such as those for type, kind, thickness, and size, are part of the inspector's responsibility. The surfaces of the skin should not show imperfections or mechanical damage. Discoloration due to heat-treatment should not be considered a reason for refusal, but it may be called to the attention of a superior. Hardness records of skins are of great importance; inspectors should pay close attention to this information.

16.16. Fitting of Skins. During the fitting and drilling of skins, inspectors can be of assistance by observing incorrect methods used or discovering other errors about to be committed. By timely prevention, costly replacements will be eliminated. Inspection of skins during and after fitting and drilling operations is carried out according to approved factory procedure.

16.17. Inspection of Skins Ready for Installation. Skins prepared and ready for installation are inspected for

1. Straight trim lines.
2. Correct rivet-edge distances.
3. Alignment of rivet holes.
4. Smooth edges of skins.
5. Condition of attaching holes (oversize, elongated, etc.).
6. Attaching holes clean and free of burrs.
7. Condition of material where counterpunched or machine-countersunk.
8. Size, location, and condition of cutouts.
9. Size, type, location, and condition of doublers.
10. Condition of skin surfaces (scratched, nicked, etc.).
11. Compliance with blueprint requirements (type of material, thickness, etc.).
12. Required hardness, particularly when heat-treated.

16.18. Inspection of Structure before Installing Skins. It is well worth the effort to look over the sections of structure for which skins are ready for permanent installation. Parts of the structure may have been damaged during the drilling of skins, temporary fasteners may not have been removed, shavings or other foreign material may not have been cleaned out, and paint specifications may not have been complied with in areas inaccessible after skins are installed. It is important that inspectors follow established factory inspection procedure during the structure-plating operation.



Fuselage cover or skin being attached. Note drilling and riveting operations in progress. (*Courtesy of Douglas Aircraft.*)

16.19. Completed Skin-covered Areas. When installation of skins has been accomplished, completed areas are submitted for inspection. They are checked according to blueprint information. Particular and close attention is given rivet requirements as shown on the blueprint, such as type and size, spacing, location, and edge distance. Inspectors should check for

1. Damaged rivets.
2. Clincher rivets.
3. Overdriven or underdriven rivets.
4. Condition of countersunk rivets (offside, too deep, or too high).
5. General appearance with respect to standards of workmanship.

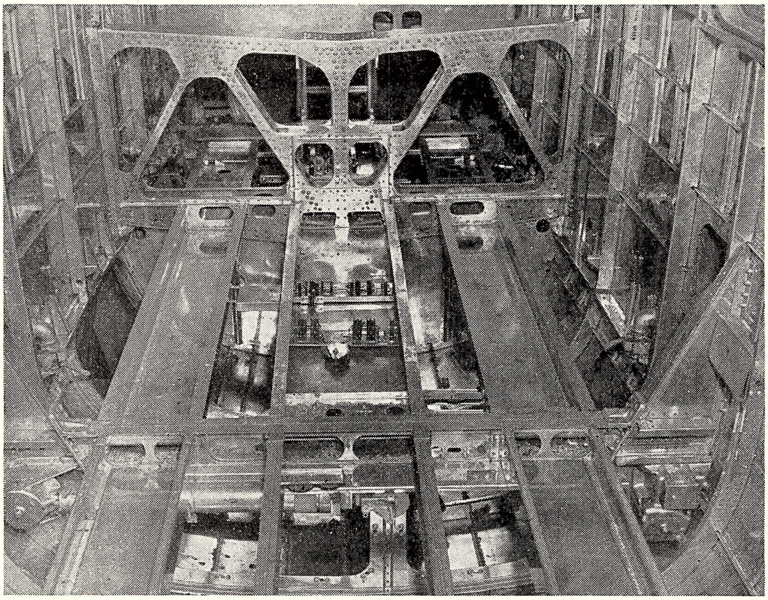
16.20. Exterior Surfaces of Installed Skins. The skins are inspected and checked on the outside of the fuselage for the following points:

1. Fit and appearance tight and smooth.
2. Trim lines straight or uniformly conforming to contour.
3. Correct rivet-edge distance.
4. No scribe marks on sheets.
5. Surface not damaged.
6. Doublers installed correctly.
7. Skin laps according to the blueprint.
8. Joggles (if any) according to the blueprint.
9. Butt joints technically acceptable.
10. Material not bulging between rivets.
11. Provisions for waterproofing as called for by the blueprint or technical specifications.
12. Cutouts located correctly and acceptable in size, etc.
13. Contoured skins not buckled anywhere.
14. Finish specifications complied with.

16.21. Interior of Covered Fuselage. On the inside of the covered fuselage, inspectors check for

1. Damaged material near rivet attachments (cracked, damaged by drills, bucking bars, etc.).
2. Edge distance at rivets.
3. Condition and appearance of rivets, with respect to standards of workmanship.
4. Shavings or other foreign material between skin and support.
5. Rivets in radius of parts or joggles.
6. Doublers in alignment as called for on blueprint.
7. Doublers matching cutouts.
8. Specified waterproofing provisions complied with.
9. Compliance with aircraft standards in general.

16.22. Completed Fuselage. The completed fuselage is inspected for compliance with all requirements such as those on the blueprint, those in authorized specifications, or those established by shop practices and accepted aircraft standards of workmanship. Inspectors are required to check the level of a fuselage before removal from the jig. Leveling pins are called for on the blueprint, and it is important that such pins be checked. When a completed fuselage is acceptable, inspectors make the required entries on records, according to established factory procedure.



Fuselage detail of flooring in a Lockheed Model 14. (*Courtesy of Lockheed Aircraft.*)

16.23. Inspection of Inner, or Center, Wing. It is impractical to attempt a description in detail of the inspection of each of the various designs. The type of the inner, or center, wing depends upon the design of the airplane on which it is to be used. There are low wing, midwing, and high wing designs, and each requires a correspondingly designed center, or inner, wing. Inspection of these conforms to the technical requirements and established factory procedure. A general description only of inspection of the inner, or center, wing will be given in the following paragraphs.

16.24. Tooling during Construction of Inner, or Center, Wings. Extensive use of tooling is made during the construction of these major assemblies. Owing to the character of wing designs, it would be most difficult to build the larger of these wings in one piece and in the same jig. However, the smaller sizes may be built in one jig.

Every step in construction is inspected. The structures are set up in subjigs to facilitate their assembly and to ensure conformity with design requirements. The utmost accuracy is demanded, for the wing actually represents a large airfoil and therefore contour is very important. Structure tooling is designed to locate and align the great number of parts and subassemblies and to produce the required results.

16.25. Inspection of Structure in Jig. As the structure takes shape, it is inspected and checked for jig attachments, alignment, and conformity to blueprint requirements. It is important that the structure should seat properly on its jig-attaching surfaces and that proper tension should hold these. No foreign matter, such as shavings, should be between the contacting surfaces.

16.26. Wing Structure. The ribs, or stations, are checked for correct alignment, clearances, and proper attachment to their individual jig positions. The stringers are put in their designed positions and attached to the rib stations. Inspectors check for alignment and for proper coordination of their anchor points at rib stations. The stringers are held by rivets, and these are inspected for compliance with blueprint requirements and standards of workmanship. The ribs are inspected closely for any damage or evidence of cracks sustained during installation and assembly of the basic structure. It is most important that specifications be complied with where points having bushings are held by jig pins. These pins are made to close limits and tolerances and should be lightly lubricated with an approved lubricant. Where bolts are installed, they are closely inspected for compliance with blueprint specifications and for safety of installation. Upon completion of the structure, inspectors check it to requirements as called for on the blueprint. Finish and process specifications affecting the work on hand are noted. Close attention is given compliance with accepted aircraft standards of workmanship. When the structure is found acceptable, it is ready for the cover to be fitted.

16.27. Fitting of Skins. During the fitting of skins, inspectors generally observe the process visually. As the various skins are removed, they check them for surface condition, straight and even trim lines, uniform edge distance, clean holes free from drill burrs, absence of damaged or elongated holes, and correct spacing of rivet holes as called for on blueprint. Should flush rivets be required, it is necessary to inspect the countersinking or counterpunching of material for compliance with technical requirements or standards of workmanship. When any doubt exists in the inspector's mind regarding material prepared for flush riveting, he should consult his superior. The structure is inspected for edge distance at rivet holes and damage sustained during skin-fitting operations. When structure and skins are accepted by inspection, the skin, or cover, may be permanently installed. Before actual installation of the covering the structure is cleaned of all dirt, shavings, or other foreign material. Should specifications require, it will be necessary to paint the structure prior to installation of the skin, or cover.

16.28. Installation of Skins. During the installation of skins, it is important that blueprint information be closely checked when waterproofing or flotation requirements are called for. Process specifications covering such requirements must be followed very conscientiously in every detail to obtain the desired results. When compartments are about to be closed up and no access to their interior is possible later, the interior is inspected for compliance with blueprint requirements, finish or process specifications, standards of workmanship, and safety of the compartment as a whole. The interior is inspected for cleanliness and absence of loose tools or foreign material. When found satisfactory, the compartment, if required, receives a paint coat for protection, and after the time needed for drying has passed it is closed up. It should be ascertained by inspectors that any installations in such compartments are complete and safe and comply with all requirements.

16.29. Doublers and Cutouts. Where doublers are installed, they are checked to the blueprint and for coordination with surfaces to which they are attached, particularly if they reinforce material around cutouts and are used for supporting inspection or access-door fasteners. Where cutouts are shown, they should be checked to dimensions as given and for any possible damage or sharp corners not conforming to radii requirements. Doublers around any cutouts should lie flat and smooth on their surface. Their means of attachment is to be noted and compared with blueprint data.

16.30. Nut-plate Installations. The installation of single nut plates or self-aligning nut strips must be inspected. It is important to check them with the blueprint for type and kind of material (steel or dural) and number of threads. Their means of attachment is checked for appearance and safety. Self-aligning nut-plate strips should be checked for alignment of the threaded part of the nut plate with the hole in the material to which they are attached. Self-aligning nut plates have only a limited movement and to forestall difficulties in later installation should align within their movement. When this type of nut plate is riveted, care is required, or otherwise the small side channels of the strip may easily be damaged and the individual nut caused to break loose when the screw is being installed.

16.31. Bolt Holes. Holes designed to receive bolt installations are checked to blueprint requirements. It should be noted whether or not any such holes are indicated as reamed holes. It is required that inspectors check any reamed hole with a plug gage of the correct size to make certain that design requirements are complied with. Bolt holes are checked and inspected for damage resulting in oversize or elongated holes. Any ridge where perhaps a bolt or pin was driven through should be noted, and close inspection given to the condition. The blueprint is to be consulted regarding edge distances near bolt holes. If any question arises as to required and safe edge distance, the inspector should consult his immediate superior.

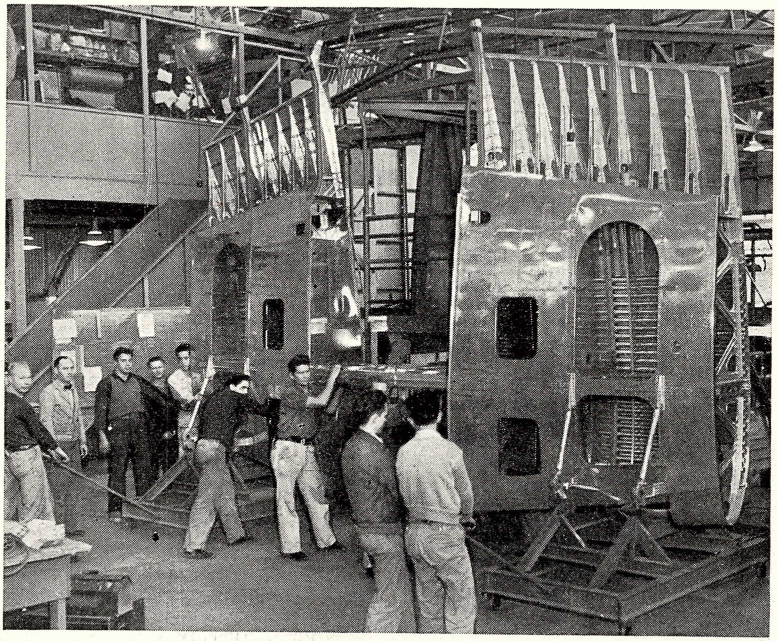
16.32. Inspection of Skins after Installation. After installation of the skins the inspector should pay close attention to compliance with blueprint requirements pertaining to rivets. It is very important that rivets of the correct type and size be used in a given location. Spacing and edge distance, condition of rivet heads, and damage near rivets by rivet guns are points to be watched. The condition of the skin is observed with respect to fit, tightness, and surface condition. The alignment of the rivets necessary to uniform edge distance and straightness of trim on the skin is noted. Where flush rivets are used, they are checked for seating and for damage by the rivet gun or "worked" material at the periphery of the rivethead. Should the blueprint call for screws to be used in certain locations for attaching the skin, these should be checked for type and kind of material, as well as for tightness, proper seating, and damaged heads caused by the slipping of the tool used to tighten them.

16.33. Skin Laps and Joints. Careful attention should be paid to blueprint information regarding size, joggle, and location of skin laps. Joggles should conform to requirements and should be smooth and of uniform depth. They should be parallel and uniform in width with the edge of the skin of which they are a part. Where butt joints are called for, they should conform to blueprint requirements or be within established authorized limits or tolerances. Areas that are covered by waterproofing specifications are checked for compliance with these. The outside of skin surfaces should be cleansed of excess material used for waterproofing purposes. Compliance with blueprint information and the safety of skin installations are the responsibility of the inspector.

16.34. Removal of Component Wing Assemblies. As the various units of a center wing are completed, inspected, and accepted, they are removed from their individual assembly jigs and transferred into one main jig for final joining. During the removal of units from their jigs, inspectors may observe the manner in which the units detach. If the unit should be of somewhat heavier weight, it should properly be lifted by mechanical means and so supported that, upon loosening from the jig, danger of damage by twisting, offside hanging, or dropping is eliminated.

16.35. Joining of Component Wing Assemblies. As the joining of units is progressing, inspectors observe the manner in which they fit together. Coordination of holes and alignment are important. Points of jig attachment or location stops are checked for matching of holes and seating of surfaces.

16.36. Final Inspection of Inner, or Center, Wing. When the inner, or center, wing is completed in its main assembly jig, it is removed, final operations are completed, and it is cleaned and submitted for final inspection. It is important that the inspection of a completed inner, or center, wing be carried out systematically and with frequent reference to blueprint and other authorized data. At all times, the inspector must keep in mind the safety of the center wing; thorough and diligent inspection will ensure this.



View of completed center section of Lockheed Hudson bomber. (*Courtesy of Lockheed Aircraft.*)

The completed article is inspected outside and inside as outlined below.

A. Outside of center wing is checked and inspected for the following items:

1. Cleanliness of outside surface.
2. Condition (scratches, nicks, dents).
3. Fit of skins tight and smooth, particularly where contoured.
4. Trim lines straight and even.
5. Edge distance according to dimensions required on blueprint.
6. Cutouts dimensionally correct and located as required.
7. Doublers installed and satisfactory.

8. Rivets correct in type, material, size, and location as shown on blueprint.

9. Screws correct in type, material, size, and location.

10. Bolt holes correct in size, location, and internal condition.

11. Bolt holes not off angle or elongated.

12. Installed bolts correct with respect to type, size, safety, and tightness.

13. Installed fittings in good condition and safe.

14. Installed fittings complying with blueprint requirements.

15. Points of attachment to jig with respect to possible damage sustained.

16. Contour and smoothness of nacelle alignment with its adjacent surfaces.

17. Finish specifications complied with, for inaccessible areas or dissimilar metals in contact with each other.

18. Trailing edges straight and undamaged.

19. Sealing specifications carried out.

20. Clearances acceptable where required.

21. Fillets installed correctly, safely, and undamaged.

B. Inside of center wing is checked for the following items:

1. Possible damage to material by rivet bucking bars.

2. Rivets acceptable and up to standards of workmanship.

3. Cleanliness of interior.

4. All required installations complete and safe.

5. Finish specifications complied with.

6. Clearances acceptable.

7. Rivets, bolts, or other fasteners not located in radii of surfaces.

8. Rivets not omitted.

9. Cotter pins installed.

10. Acceptable thread penetration on stop nuts.

11. Edge distances according to requirements.

12. Installation of fittings correct and safe.

13. Unsatisfactory conditions, such as cracks or bend flanges.

14. Compliance with special blueprint requirements such as for the omission of rivets where subsequent parts are to be installed.

15. Seals at tank-filler necks according to blueprint.

16. Correct material used in such sealing installations.

This enumeration provides a general basis for final inspection. Other methods are possible and will depend on differences in design and size of the product and in the procedure of the individual factory. In general, successful and dependable results are obtained if the inspector is determined to

1. Master the blueprint information.
2. Be familiar with shop practices and standards of workmanship.
3. Know the finish specifications and processes.
4. Inspect systematically.
5. Apply himself and concentrate on his work.
6. Be conscientious and diligent.
7. Keep informed of all information newly released.
8. Ask the advice of his superior when in doubt.
9. Be cooperative with and helpful to production personnel.
10. Live up to the meaning of his inspection stamp.

16.37. Inspection of Outer Wings. An outer wing consists of the main body of the wing and the wing tip. The wing tip may be detachable or not, depending on design. Owing to differences in design and the consequent varying of building methods, the discussion of wing inspection will be on a general basis.

16.38. Outer-wing Structure and Cover. The foregoing discussion of inner-, or center-wing structure and skin, or cover, applies to outer-wing structure and cover. However, there are additional remarks to be made here.

1. Correct and proper use of tooling provided. It is important that tooling points of attachment should be clean and that the parts matching or resting on such surfaces should match and coordinate and should not be overtightened. Threaded parts require particular attention. They should be lubricated with an approved lubricant, carefully threaded through, and *not* overtight. Damaged threads will result from careless installation of such fittings. Rib-station stops are not to be bent; they should be straight, holding the wing ribs in their proper location and alignment.

2. Alignment of structure. Longitudinal stringers and spars should be in correct alignment and the safety of installations checked very closely. Clearances between stringers and cutouts in ribs must be acceptable, and the taps holding the stringers must be securely fastened as called for on the blueprint. Close

inspection should be given these rib tabs for cracks at radii and a preloaded or twisted condition. At no place should the structure show indications of strain, misfit to tooling, or other conditions indicating undesirable preloads. The inspector should bring any such condition to the attention of his immediate superior.

3. Compliance with finish specifications. This is very important, particularly so when the design calls for waterproof wing compartments, commonly known as "flotation provisions." The procedure outlined and materials used for such provisions must be followed very carefully and to the letter. It is necessary that all surfaces, areas, and joints be clean and free from dirt, grease, shavings, dust, etc., in order to ensure good results. Areas before permanent closeup are thoroughly inspected for completeness of all required installations, compliance with blueprint information, cleanliness, and loose articles or tools left inside them; the sealing provisions must be carried out, standards of workmanship acceptable, and the areas under inspection pronounced ready and safe for closeup.

4. Condition of cover. Skins are inspected for appearance, tightness, fit, and damage such as scratches, nicks, or dents. Particular attention is given the requirements on the blueprint regarding type, size, number, spacing of rivets, and required edge distances; trim lines must be straight and matching the curvature of the contour, skins should not buckle between rivets, and laps must be located correctly and according to blueprint requirements. Of particular interest is the nose, or leading-edge section, of the wing. Its surface is to be smooth in appearance and contour, and it is inspected closely for any nicks, dents, or loose sections of skins and for straightness. The contour must be uniform and should have no flat areas. Cutouts, doublers, and corresponding coverplates are checked for blueprint compliance and acceptable, safe installation and fit. A uniform specified clearance between plate and cutout is necessary, and all fastening provisions for plates in doublers of cutouts are closely inspected for safety of installation and satisfactory standards of workmanship.

16.39. Safety of the Outer Wing. In inspecting an outer-wing assembly, it is important that the safety of the entire unit be constantly in the mind of the inspector. Only by following all blueprint requirements and all specifications and by keeping to the highest standards of workmanship is the safety of an outer wing guaranteed. Whenever the slightest doubt exists in the mind of the inspector as to the safety of any part of an outer wing, he should consult his superior without fail.

16.40. Inspection of the Landing Gear. There are two types of landing-gear design used on modern airplanes, as follows:

1. Landing gear using a nose wheel, called a "tricycle" landing gear. This consists of one main landing-gear unit mounted on each inner wing, or wing nacelle, and a landing-gear unit mounted in the nose of the fuselage.
2. Landing gear using a tail landing wheel. This gear consists of one main landing-gear unit mounted on each inner wing, or wing nacelle, and a landing-gear unit mounted in the tail section of the fuselage. The tail wheel may be designed to be retractable or nonretractable.

All landing-gear units are provided with a shock-absorbing unit, which absorbs, by the use of hydraulic fluid, the shocks imposed.

16.41. Landing-gear Wheel and Tire Installations. The assembly of landing-gear units is accomplished by specially trained mechanics engaged in building up, assembling, and testing the various parts and assemblies comprising a complete landing-gear unit. Attention is given specified alignment and clearances of the brake mechanism, correct tension of installation bolts and nuts, and their required locking or safety devices. Tires and tubes are checked for condition and identification as to balance and as to part number. It is important to see that tubes are prepared for installation as called for in the manufacturer's service information and that the correct methods are used when tires are installed on the wheels. It must be ascertained that the tube is not kinked or wrinkled inside of the tire. The full amount of air should not be put into the tube until the tube is in perfect position for full inflation. Balance marks on tires are to be located according to requirements, and the tube valve stem should not be offside in its opening. It is important that the entire wheel assembly be checked for proper balance by approved factory methods and equipment. Authorized balance tolerances are to be checked. When the inspector is doubtful about any point, he should consult his superior.

16.42. Landing-gear Wheel and Axle Installation. The installation of a landing-gear wheel assembly must be carefully accomplished. When the wheel assembly is put on its axle, caution should be used to prevent damage to the threads on the axle. It is necessary to inspect bearing cones carefully, and bearings must be thoroughly clean and free from dirt or other foreign material. The condition and fit of bearing cones are closely checked, and the bearings themselves are turned by hand and inspected for general condition, identification as to make and type, and any roughness while turning. Before the installation of bearings and bearing cones, they must be lubricated with an approved lubricant according to factory specifications.

16.43. Wheel Installation. The inspector must check the adjustment of the wheel retaining nut and its safety of installation. It is required that proper and correct wrenches be used, and approved factory methods should be followed in detail. The cover, or dust-cap, provisions on the installed wheel are inspected for fit, appearance, tire slip marks, and general safety as given in factory specifications.

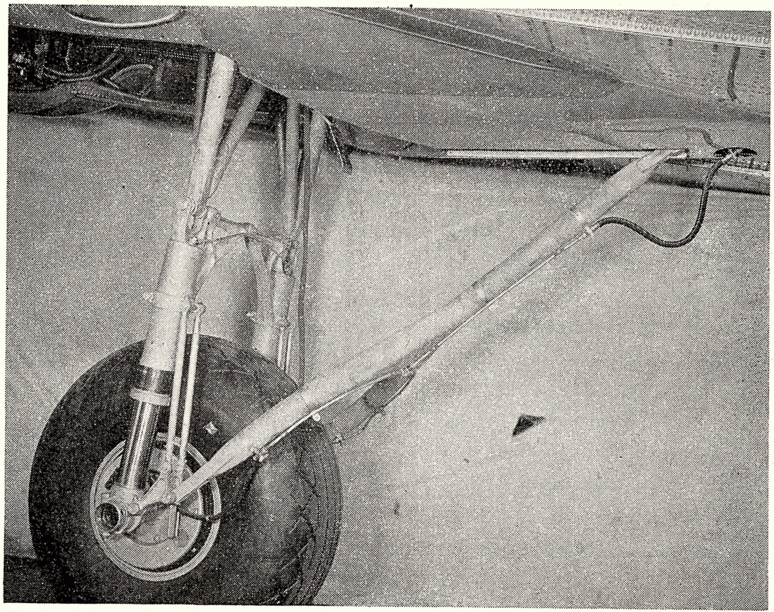
16.44. Landing Gear during Assembly. As the various units are attached to each other, it is important that alignment between parts be accomplished *without force.* Inspectors should check closely for condition of bearing surfaces, compliance with lubrication specifications, and correct type, kind, length, tension, and safety of all bolt installations. The blueprints must be consulted frequently for important information such as requirements for special bolts or bearing bolts. The installation of any hydraulic shock-absorbing or landing-gear actuating units must be inspected. Their alignment, fit, clearances, and safety of installation are checked, and also their identification, or name, plates and acceptance stamps.

16.45. Flexible Hose Installations. Flexible hose connections installed on a landing gear unit, such as brake hoses or hydraulic-operating strut hose connections, are inspected for security of connection. Any twists are noted by observing the lengthwise color-band alignment. The general surface condition and safety of installation should be checked.

16.46. Final Inspection of Landing-gear Unit. Upon completion of a landing-gear unit, it is closely inspected for compliance with blueprint and all other specifications and standards of workmanship. After acceptance by inspection, it is tested for operation in a specially constructed jig. When all the required tests and operations are satisfactory, the entire unit is accepted by inspection and authorization given for installation on the airplane itself.

A landing gear being installed on a Douglas Model DC-3 airliner. (*Courtesy of Douglas Aircraft.*)

16.47. Installation of Landing-gear Unit on Airplane and Final Inspection. The method and procedure for installing a landing-gear unit depend on the design and equipment provided by the factory. In general, the inspector must see that all bearing surfaces are clean and that lubricating fittings are installed and unobstructed. Bearing surfaces should be lightly lubricated prior to the installation of bolts. The alignment of attaching joints is important. Force should not be resorted to in making the installation. The parts should be held in alignment in such a manner that bolts can be installed with only the reasonable resistance actually caused by close tolerances between bolt and hole diameters. It is important that all information given on the blueprint regarding installation, such as directions for special washers or for the location of spacing washers, be complied with in detail.



The landing gear installed, note the neatness of tubing installation. (*Courtesy of Douglas Aircraft.*)

The completed installation is inspected and checked for safety of all parts and their connections. The general condition of units with respect to surface damage, etc., is checked. Compliance with technical requirements such as those for special bolts used in spacing washers of correct location, alignment being thus ensured, is checked. The installation is inspected according to the requirements of authorized factory finish specifications and good standards of workmanship. When found satisfactory, the installation is accepted, and a record made.

CHAPTER XVII

FLIGHT-CONTROL SYSTEMS

The inspection of flight-control systems carries great responsibilities. In no instance should safety be compromised. It is suggested that inspection personnel take the principles formulated in this chapter as a guide, for they are based on requirements applicable to all types of surface-control system. Attention is called to the importance of authorized factory information, such as blueprints, specifications, and special requirements. Inspectors should be thoroughly familiar with these in order to be equal to their task of safe and dependable inspection of flight-control systems.

17.1. Parts Making Up the Flight-control System. The flight-control system may be divided into four parts, as follows:

1. Structural supports and guides.
2. Cables and control tubes.
3. Control surfaces.
4. Operating the system.

17.2. Structural Supports and Guides. The means of supporting a control system is important. Inspectors should check with care all supports and guides and their condition, attachments, and the safety of their installation.

1. Pulley supports. Pulley-support castings or brackets should have sufficient clearance with adjacent surfaces or structures. Edge distances at points of attachment are checked, and the means of attachment inspected. Where rivets are used they should conform to blueprint specifications and accepted standards of workmanship. Should bolts be used for attachment, they are inspected according to requirements for type, kind, and safety. All holes used with bolts should be of correct diameter, clean, and undamaged. Where supports are nested into a structural support, their radii should match the radii of the structural support. Pulley brackets made of sheet metal are inspected for possible cracks at radii bends and for parallel

sides. Installation of cable guards is given attention for condition and safety.

2. Pulleys. These are inspected for correct type, size, material, damage, rough or defective bearings, and warp. On permanently sealed bearing installations, the fit of the seal and its condition are noted. It is important that blueprint information be followed in regard to pulleys and their correct use and location.

3. Pulleys installed in their supports. The following points are noted in inspecting installed pulleys:

a. Satisfactory clearances between pulley and its support through a full revolution.

b. Satisfactory clearances between a number of pulleys when "cluster" installations are made. Pulleys must not touch each other during a full revolution of the adjoining pulley.

c. Satisfactory clearance at cable guard.

d. Safety of pulley center-bolt installation.

e. Cleanliness of installation. The pulley installation is checked for presence of foreign material, such as small bolts, screws, nuts, or pieces of safety wire, which may be lying on or between pulley and support or may wedge into controls when operated.

f. Pulleys should not bind during range of movement.

4. Fairleads are considered guides rather than supports. Because their surface is stationary and the cable moves across this surface, the friction between these two parts should be held to a minimum. It is important that fairleads be made and installed according to blueprint requirements. The slot used to install a cable in its hole in a fairlead is arranged so as to make it impossible for the cable to work its way out of the fairlead. Fairleads are inspected for possible cracks near these slots. The size of the hole in a fairlead should be sufficient to show clearance between the cable and the sides of the fairlead, in order to reduce drag to the minimum. The installation and safety of fairleads are important, and inspectors should pay close attention to these units.

17.3. Cables and Control Tubes. Cables and control tubes of flight-control systems play a most important part in their function and in their dependable and safe operation. Inspectors assigned to their inspection are to check these parts with care and according to all blueprint and other specification requirements. Cables are checked for

1. Correct type and size. The blueprint will give requirements, and the cable types and sizes are definitely to agree with these.

2. Correct size and type of turnbuckles (as a long or a short type). Freeness of threaded connections is noted, and also compliance with approved lubricant specifications. Threaded parts must turn reasonably freely and should not bind at any place. Right- and left-hand threads are checked for correct direction, and the type of cable-end connection must agree with blueprint requirements. Threaded parts are lubricated with the lubricant mentioned in factory specifications, and all excess lubricant should be wiped off.

3. Condition of cable "serving." This should be undamaged and its protective coating in good condition.

4. Identification by colors, if called for in factory specifications. This is important; it is checked for compliance with the color code and the size of the color band. The identification color is generally applied at the serving of cables.

5. Damage. Cables are closely inspected for broken strands, burns from soldering irons, or evidence of having been drilled into or kinked. Cables are to be clean and free of material such as masking tape, pieces of loose safety wire, or other foreign material that may endanger the installation during operation.

6. Clearances at cable guards. This is important, particularly with respect to the amount of clearance consistent with the safety of the installation.

7. Cable connections. These are inspected for number of threads exposed after correct adjustment of cable (three threads maximum on each side of the turnbuckle barrel) and the type, size, kind, and installation of safety wire (see Fig. 52).

8. Cables on cable control drums. These are inspected and checked according to the details given on the blueprint. Where a setscrew is used, it is very important to see that this screw and its locking arrangement are holding the cable as required without endangering the condition and safety of the cable itself. Control drums are checked to see that all finish specifications have been complied with prior to installation of the cable, that cable grooves are in good condition, and that the cables them-

selves fit and lie correctly in their grooves. The cable-drum unit itself is visually inspected for general condition, lubrication requirements, and safety of the unit and its installation.

9. Rotating cable-operated connections. All cable-operated connections that are subject to partial or full rotating movement are checked for freeness and absence of any binding. All bolted connections are checked with blueprint information for type, material, and length of bolts and the safety of their installation.

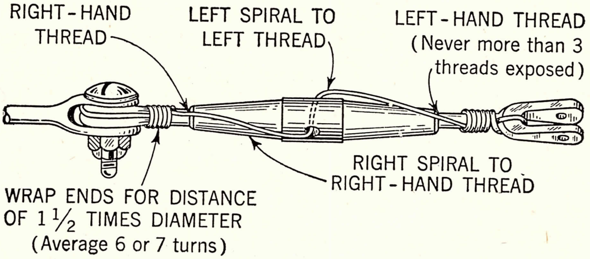

RIGHT-HAND THREAD
LEFT SPIRAL TO LEFT THREAD
LEFT-HAND THREAD (Never more than 3 threads exposed)
RIGHT SPIRAL TO RIGHT-HAND THREAD
WRAP ENDS FOR DISTANCE OF 1½ TIMES DIAMETER (Average 6 or 7 turns)

Fig. 52.

10. Control cable adjustment must comply with authorized specifications and is checked with a tensiometer of approved type.

17.4. Rigid-control Connections. Rigid-control connections such as levers, tubes, rods, and bell cranks are checked according to blueprint requirements and inspected for safety of installation, correct functioning during operation, and acceptability from the point of view of good standards of workmanship. They are inspected and checked for

1. Correct installation and adjustments. They should be adjusted so as not to be under a load created by misadjustment.

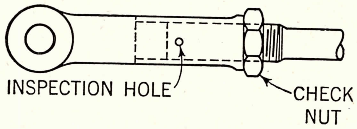


Fig. 53.

2. Proper alignment of end connections. They should be aligned and free from a twisted condition and should not bind at any point of movement.

3. Safe clearances with parts of the airplane at all points. Particular attention should be given installations where a number of rigid-control units are installed side by side.

4. Locking of jam nuts. These are checked for tightness. Thread penetration is investigated through the inspection hole located in the end connections (see Fig. 53).

5. Self-aligning bearings. These are checked for safety of installation, any evidence of damage, and proper alignment of their connections.

6. Long control tubes supported by rollers or other means. These are inspected according to blueprint requirements for freeness, alignment with their supports, and safety of installation; they must conform to good standards of workmanship.

The inspection personnel should be most diligent during inspection of the control-system installation. The safety of any part, no matter how small, should always be considered of paramount importance.

17.5. Flight-control Surfaces and Their Installation. Control surfaces are inspected and checked to ensure their correct installation, operation, and safety. Inspectors must follow the blueprint data in detail; compliance with these, as well as with specifications and good standards of workmanship, is most important. Inspectors check these units and their installation for

1. Alignment of trailing edge with adjacent surfaces. This also includes checking to see that the trailing edge of the control surface itself is not warped.

2. Condition of surface covering (no holes, tears, blemishes, or loose covering).

3. Foreign articles left inside. This is checked by turning the unit over and listening for noises of falling or rolling articles.

4. Drain and air holes open and clean. These holes are located on the underside of the surfaces only.

5. Attaching fittings attached properly, securely, and safely. These are checked for installation of cotter pins or safety wire, whichever the blueprint calls for, alignment of these fittings, and freeness from damage.

6. Conditions of bearings (no poor staking or spinning; no damage by wrenches).

7. Threads within requirements on actuating rods (threads visible through inspection hole).

8. Locking nuts tight at rod connections. These should be checked not only visually but by trying with the fingers.

It is important that unsatisfactory conditions be definitely found and eliminated. The safety of these units and their installation is of the greatest importance.

17.6. Inspection Preparatory to Operation. The operation check, or so-called "roll-out," of a control system requires the most careful attention of inspectors. The purpose of this check is to prove that the system operates as designed, that specific results are obtained by its operation, and that the system is safe in all respects.

17.7. Cable Tension According to Specifications. Before actually operating any system, it must be ascertained that its operation does not endanger the safety of men or equipment. Inspectors must also check the required tension of cables and make certain that it is as set forth in factory specifications.

17.8. Start of Operation Check. When the system is ready for its operation check, the inspector should pay close attention to the amount of physical effort required to operate it. He should note whether or not any unusual effort is required to operate it, and any other condition demanding attention, such as a "rubbing" noise. While the system is being operated slowly over its entire and full range of movement, inspectors should check the system from one end to the other.

17.9. Operation Check in Neutral Position. The inspectors operating the system should first check the system when in neutral. The control surfaces are to be in alignment, and all control operating units should be checked for the correct position according to the installation blueprint. When the system has been found satisfactory while in neutral, it is checked for correct functioning and operation.

17.10. Operation Check on Control-system Installations. The inspector operating the system should put each part of the system separately through its complete range of movement, for example, the rudder-control system, elevator-control system, and aileron-control system. This method facilitates inspection procedure, and unsatisfactory conditions are more readily traced and located.

The inspector should pay close attention to the amount of physical effort required to operate the system. If an unusual amount of effort is required or any other unusual condition is noted such as a "rubbing" noise, the entire system in question must be carefully inspected and checked while it is being operated slowly over its entire range of movement. This is to be continued until the cause of the unsatisfactory condition has been definitely established and corrected.

17.11. Operation Check of Movement of Control System. During movement of the control system, the inspector should check carefully for satisfactory and safe clearances between movable parts of the system and between movable parts of installations and stationary parts of the airplane. The movement of the control system is to be from one extreme end of travel to the opposite end of travel.

17.12. Control Column, or Stick. The setting of the control column, or stick, is observed during the operation and the amount of clearance noted between parts of the airplane when control is in its extreme forward or aft position. Also, clearances when ailerons are operated are checked.

17.13. Overtravel. Close attention is given any part of the system subject to possible *overtravel.* Incorrect adjustments may permit overtravel past dead center, which would make return movement impossible. Bell cranks are inspected for such a possibility. Clearances and safe travel movements of these are vital.

17.14. Self-aligning Connections. Units that have self-aligning bearings in their connections are closely inspected for their initial clearance between parts of these connections. The initial clearance must be sufficient to ensure proper and safe clearance at positions of full movement. This is most important; for if the initial clearance is too small, the clearance will be used by the bearing connection before the full travel movement is reached. Consequently, a preloaded or overtwisted condition is created, endangering the safety of such a connection.

17.15. Cable-adjusting Turnbuckles. During operation of the system, inspectors check the movement of cable-adjusting turnbuckles. They should not interfere with each other during movement and should not touch cutouts, pulleys, or fairleads. They should not endanger the safe and proper function of a control system. Control cables should have no possible opportunity of vibrational contact with each other or any part of the airplane. The cables should enter pulleys or fairleads in proper alignment and within limits or tolerances established by specifications. Friction in a control system is energy loss, which means extra work for the pilot and more wear and tear on material and which affects surfaces in their return to neutral. Fairleads are not used for directional changes but are for the purpose of supporting a cable and to prevent vibration in it.

17.16. Proper Cable Alignment. Cables are to enter pulleys and fairleads within the following tolerances, unless otherwise authorized:

Pulleys:

1. Fixed-alignment tolerance, 1 deg.
2. Variable-alignment tolerance, 1 deg. for neutral position of control, 2 deg. for any position between half and full movement of controls.

Fairleads:

1. 2 deg. when cable tension is less than 50 lb. initial tension.
2. 1 deg. when cable tension is 51 to 150 lb. initial tension.
3. No deflection permitted if cable tension is over 150 lb.

17.17. Direction and "Throw" of Flight-control Surfaces. The operation check is made of the control system for the purpose of determining the correct movement of control surfaces as to direction and amount of movement. The directional check is made to make certain that no controls are hooked up wrong. This check is very important. The amount of movement, or "throw," of control surfaces must be according to specifications or within approved limits and tolerances. The measurements are to be taken when it is certain that provided stops have been reached. It is necessary that inspectors check closely the safety of "stop" provisions and make definitely sure that controls rest against provided stops as required.

17.18. Flight-control Trim Tabs, and Their Installation and Movement. Flight-control trim tabs, their installation, tab-operating system, and controls are inspected like the flight-control system. In addition, it is to be observed that the indicators on the control units correspondingly indicate the positions of the tab units themselves; for example, in neutral, the pointer should show neutral; 5 deg. left or right, up or down, should show the same at the control unit. Actuating cable drums should be operating satisfactorily and cables resting safely in their cable-drum grooves. The tab system is to conform to blueprint requirements, specifications, and good standards of workmanship. The safety of the system should be established prior to acceptance by inspectors.

17.19. General Procedure for Flight-control Inspection. To facilitate inspection, an outline of procedure follows, to be used as a guide by inspectors.

Flight-control mechanism. *Check all surface controls for freedom of operation.*

- I. Rudder-control system.
  - *A*. Inspect rudder pedals for proper condition of pedal bearings and pedal-adjusting mechanism.
  - *B*. Check for lost motion.
  - *C*. Check position of rudder with rudder pedals in neutral.
  - *D*. Inspect safetying at all joints and connections.
  - *E*. Inspect for frayed cables and for condition of servings.
  - *F*. Check for misaligned, bent, loose, broken, or cracked pulleys.
  - *G*. Check condition of all pulley supports for tightness and safety of attachment.
  - *H*. Check clearance and freedom of interference between rudder and elevators in extreme throw positions.
  - *I*. Check condition of cable color banding.
  - *J*. Check cable tension.
  - *K*. Check entire tab system for
    1. Security and safetying of all cables, rods, and attachment fittings.
    2. Condition of cables, pulleys, fairleads, rods, and operating mechanisms.
    3. Signs of interference with other parts.
    4. Cleanliness of cables.
- II. Aileron-control mechanism and system.
  - *A*. Inspect aileron-control wheel assembly for proper condition and functioning. Also, check the condition and cleanliness of all bearings of the control-column mechanism.
  - *B*. Inspect entire aileron-control system for
    1. Lost motion.
    2. Proper safetying of all joints and connections.

3. Frayed cables and condition of servings.
4. Misaligned, bent, broken, or cracked pulleys.
5. Condition of all brackets and supports.
6. Position of ailerons when control column is in neutral.
7. Cable tension.
8. Proper functioning of tab controls.
9. Operation of tab indicators, being sure that they show correctly the position of the tabs.
10. Entire tab-control system for
    - *a.* Security and proper safetying of all cables, rods, and attachment fittings.
    - *b.* Condition of cables, pulleys, fairleads, rods, and operating mechanism.
    - *c.* Signs of interference with other parts.
    - *d.* Amount of tension on tab-control cables (feel it).

III. Elevator-control mechanism.
- *A.* Inspect elevator-control-column assembly for proper functioning.
- *B.* Note effort required to move elevators.
- *C.* Check for lost motion.
- *D.* Inspect safetying of all joints and connections.
- *E.* Inspect cables for fraying; inspect condition of cable servings.
- *F.* Check for misaligned, bent, loose, cracked, or broken pulleys and pulley supports.
- *G.* Inspect condition of cable-identification color banding.
- *H.* Check position of elevators, when control column is in neutral.
- *I.* Check for any interference in the entire system during full-throw operation.
- *J.* Check entire tab system for
    1. Security and safetying of all cables, rods, and attachment fittings.
    2. Condition of cables, pulleys, fairleads, rods, and operating mechanisms.
    3. Signs of interference with other parts.
    4. Cleanliness of cables.

Flight-control surfaces: *Inspect all surfaces for holes or other visible damage and for general condition.*

Ailerons, elevators, and rudder must be checked and inspected for

1. Free and full movement.
2. Compliance with throw requirements.
3. Warping.
4. Broken ribs or loose ribs (this check is required particularly after flight).
5. Condition of covering (inspectors must check for loose rivets, tears around rivets, or covering becoming loose around nose section).
6. Signs of interference.
7. Condition of bonding pigtails.

17.20. Conclusion. Inspection of flight-control systems is exacting and important. The safety of such systems is the responsibility of inspection. Familiarity with blueprint requirements, specifications, and accepted aircraft standards of workmanship is essential.

CHAPTER XVIII

FUEL AND OIL SYSTEMS

18.1. Introduction. The safety of personnel and equipment of the airplane is constantly endangered by the possibility of fire, especially while the airplane is in flight. The high volatility of present-day aviation gasoline favors the development of highly explosive gases from any leak, no matter how small.

For this reason alone the entire fuel system must be leakproof. This can be successfully accomplished only if everyone does his work to the best of his ability during the progress of assembling and installing the fuel system. Inspectors should take their work most seriously and should apply themselves diligently and thoroughly. It is most important that all requirements be followed as given in blueprint requirements, specifications, and any other authorized information. Whenever in doubt, the inspector should consult his immediate superior for advice.

18.2. Inspection of Fuel Tubing before Installation. Before any tubing is installed, the interior of the tubing must be clean and free from any obstruction. However, the covers on the opening of the tubing should be removed for inspection of the interior just prior to actual installation. The tubing is inspected for general appearance and condition. The surface should not be damaged, and all threads are to be in perfect condition. Flares on tubing must not be damaged and are to be free of dirt or other foreign material. Tubing bends are checked for correct diameters.

18.3. Fuel-tubing Supports. Supports for fuel tubing are inspected for condition and safety of installation. The means of attachment are checked to the blueprint and according to standards of good workmanship. The safety of tubing supports is a primary requirement.

18.4. Lubricant Specifications. Lubricant specifications are issued for threaded parts in the fuel and oil systems. It is important for inspectors to be familiar with such specifications and to check on how closely they are complied with when inspecting tubing installations. Lubricants specified for liquid-carrying lines are chosen because of their ability to withstand the chemical action of fuel or oil.

18.5. Tubing Installed in Supports. Tubing passing through supports such as clamps or tubing blocks is to fit correctly into these supports. The clamps should be installed so that any bend of tubing is not within a support. The tubing should not pass through a support at an angle. Clamps of the correct type and size must be used. Clamps or block supports must not be overtightened, or the safety of tubing and its supports will be endangered. On tubing blocks supporting a number of lines in which only part of the openings are used, specified spacers of correct diameter should be installed in the unused openings. This will prevent distortion of such tubing blocks upon tightening of support installation bolts.

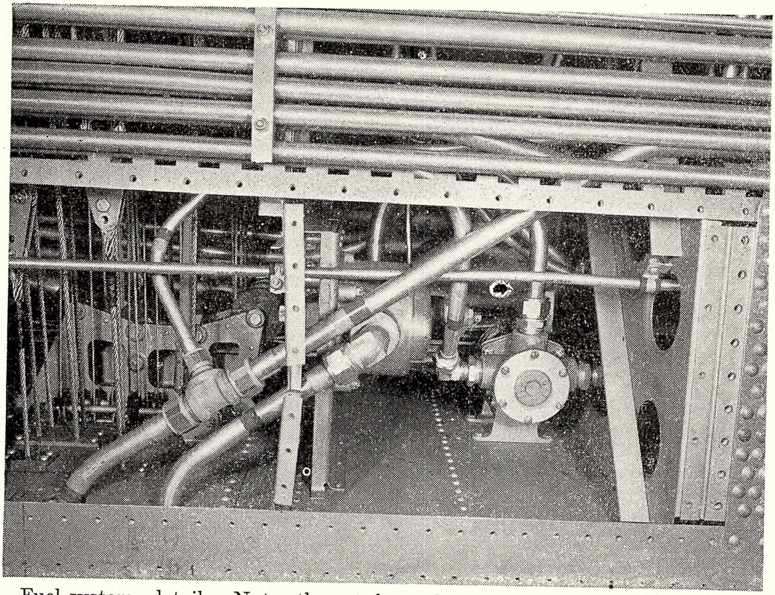
18.6. Antivibration Provisions on Tubing. Conditions that expose tubing to rubbing, chafing, or vibration are to be corrected wherever found. Lacing material (see Sec. 18.7) such as rawhide or composite materials containing chloride should not be used in contact with aluminum or aluminum alloys.

18.7. Lacings. All lines except those in the engine section where temperatures exceed 150°F. are tied where necessary with a plastic strip material of specific composition and width. After the ties are completed according to the specified method, no finish of any kind is applied to them.

Lines or tubing in the engine section or where temperature may exceed 150°F. are tied with strips of oil-tanned leather made to certain specifications. Cord is used for the same purpose when specified. To protect and preserve leather or cord lacings on aircraft lines and fittings after their installation, they are covered with a heavy brush coat of clear lacquer; the lacquer coating is to extend or overlap the adjacent surfaces ½ in.

18.8. Clearances. Clearances on tubing installations are checked closely. They must be sufficient to exclude any possibility of tubing making contact for whatever reason. Particular attention should be given clearances near tubing connections, where tubing passes through cutouts or alongside of structures or other movable equipment such as control cables.

18.9. Alignment of Tubing Connections. It is very important that inspectors note the tubing alignment at connections. No tubing should enter its connection at any angle, for this definitely constitutes a condition the consequence of which will be failure of the connection. Perfect alignment is essential. It is also unsatisfactory to connect a tubing that is too short by pulling it into a connection by means of the nut on the tubing end. This, too, will be a dangerous condition, for the flare takes the punishment of the forcing together, though not designed for that purpose. The principal and real purpose of the flare is to make a seal at the connection.



Fuel-system detail. Note the perfect alignment of tubing connections, identification on tubing, rubber-protected tubing support clamps, lines of tubing held in tubing-support block, and general neatness of tubing installations. (*Courtesy of Douglas Aircraft.*)

18.10. Bonding Provisions. Fuel- and oil-system tubing installations are required to conform to bonding specifications. Inspectors check compliance with such specifications by the use of an ohm-resistance-measuring instrument of approved type.

18.11. Hose Connections. Hose connections on fuel and oil systems are made of special material. For easy identification of this material the manufacturer incorporates one or two red stripes or one white and one red stripe running longitudinally or in a spiral around the body of the hose. Inspection should check for this identification.

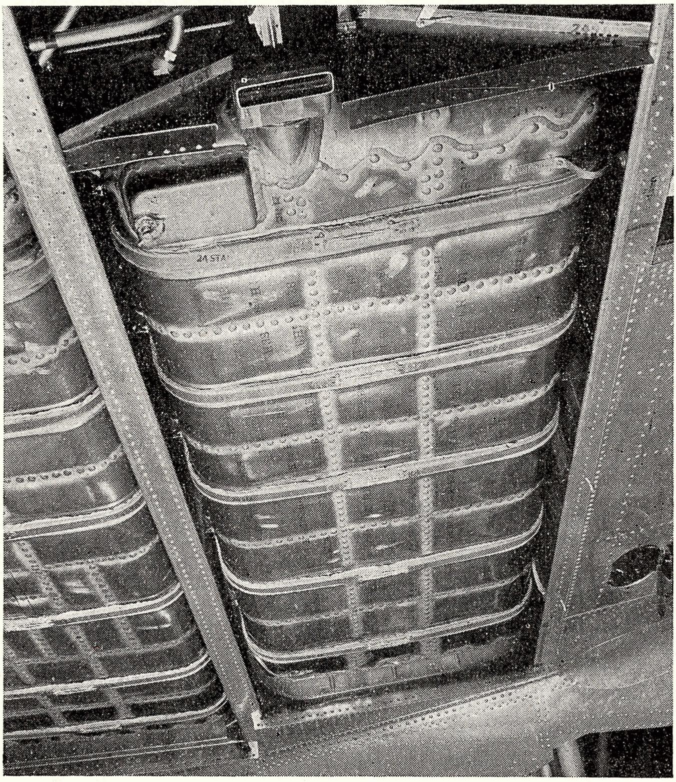
The installation of a hose connection is inspected for compliance with blueprint requirements such as length, size of hose material, and type, size, and material of hose clamps. The ends of the tubing must extend into the hose connection as specified, and they should not rest against one another. Should the ends of tubing be beaded, inspectors are to note whether or not the hose clamps are located back of such beads and whether sufficient contact is maintained between the clamp and the end of the hose connection. At no time should clamps extend beyond the end of a hose connection. Clamps on hose connections are not to be overtightened. Hose-connection clamps are to be inspected carefully for any possible damage sustained during installation, such as stripped threads, the clamp not at 90 deg. to the hose connection, bent clamp, cracks at the radii of the clamping guides, or damaged by pliers during tightening.

18.12. Bonding Requirements for Hose Connections. Bonding specifications for hose connections are to be complied with. Inspectors will check for this.

18.13. Identification of Tubing. Identification of tubing must correspond to specifications with respect to both color and location. The color should be applied in a neat and uniform circular band. Identification color bands are usually located at a specified distance on either side of a tubing connection or at any other part on the tubing deemed advisable to facilitate tracing of the tubing in the system.

18.14. Fuel-system Units. Units such as fuel wobble pumps and directional-flow valves are closely inspected for correct attachment according to blueprint requirements and for safety of installation. All connections between these units and other parts of the operation arrangements are checked and inspected for safety, alignment, clearances, correct movement, and range of travel and for compliance with blueprint requirements and other specifications. These units and their installation, general condition, and connections are visually inspected according to accepted aircraft standards of workmanship. Specifications require that such units as strainers, valves, wobble pumps, and their handles be identified by a specified color; inspectors are to check for compliance with such specifications.

18.15. Tubing Connections at Fuel-system Units. A close inspection should be made of units where tubing connections are made. Should the union, or connection, be made with excessive wrench force, it is very possible for the material of the units to crack at such a connection. Only by close inspection can such cracks be discovered, but it is highly important that they should be detected. They may not show a leak at the time; but vibration will widen such cracks, and failure will result.



Fuel-tank installation detail in a Douglas Air-liner. Note the tank-support strops, fuel-dump valve, and bonding provisions. (*Courtesy of Douglas Aircraft.*)

18.16. Fuel Tanks. Inspectors checking fuel or oil tanks should note carefully whether or not any damage exists. The interior of any tank must be clean and free of any foreign material. Filler necks, their sealing installations, and overflow drains are to comply with all requirements.

Should tanks be removable, inspectors are to check the installation and safety of tank-suspension provisions. Reference to the blueprint is advised, for it is most important that its requirements be complied with in detail to ensure the safety of a removable-tank installation. Clearances between tank and adjacent structures must be sufficient and safe. Strainers, their condition, and their safety are noted; necessary bonding provisions are checked for safety of installation and compliance with resistance-reading specifications.

Tanks that are "built in" and are a part of the inner, or center, wing are inspected during the building of this unit. They are checked for the condition of exposed fittings and their threaded connections.

18.17. Inspection personnel assigned to check and inspect fuel or oil systems should familiarize themselves with the various directions of flow of the liquid in these systems. All necessary information is shown on specific flow blueprints, and only by consulting these can correct and reliable information be obtained. The correct routing, or direction, of the flow of liquid in relation to control-unit settings is of the utmost importance. Inspectors should realize their responsibility in this respect.

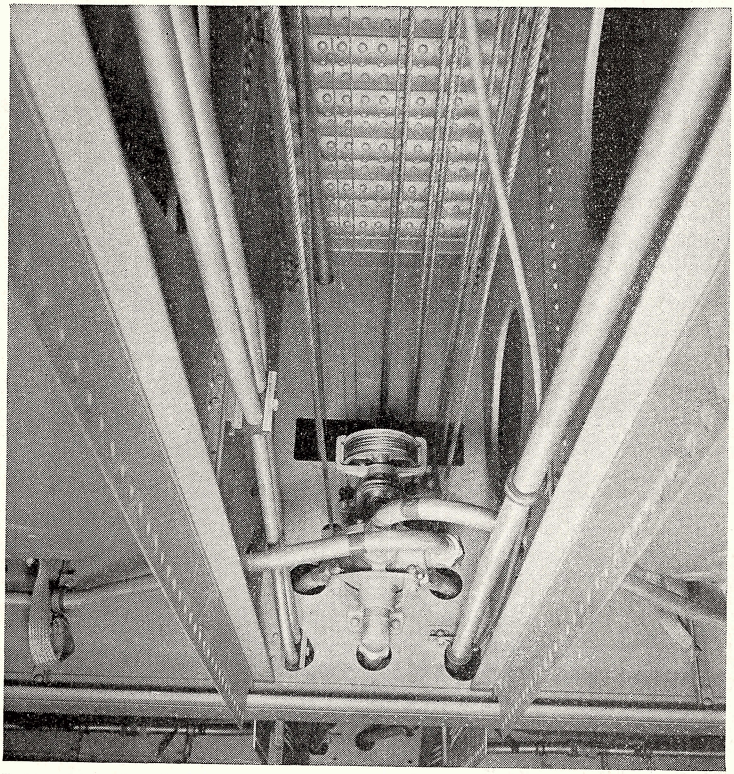
18.18. Fuel Valves, Controls, and Control Connections. Valves and controls have certain specific settings; the identifications of these settings are shown on the blueprint. Only by referring to the blueprint can the inspector recognize and check the correct settings and make sure of the correct functioning of the valves.

The routing of flow is checked by means of air being released into the system after the controls have been set in a known position. The procedure in these operations is according to authorized factory specifications suitable to the design requirements.

Controls and their connections are inspected and checked as explained in Chap. XVII with respect to the flight-control system.

18.19. Checking Valves for Operation. Inspectors should take special note of the way in which the different positions of the control system may be identified. The different positions may be heard as a "clicking" sound when the spring-loaded position lock slides into place, but in all cases a definite "feel" transmitted through the controls involved should be felt by the operator when a lock position has been reached.

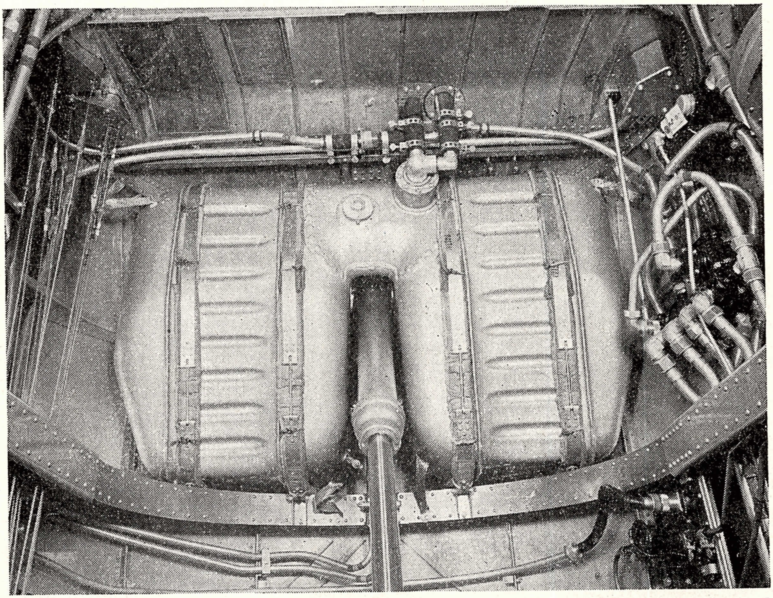
To check the amount and definite entry into a lock position a practical method is to operate the selector control from one end of its travel to the other in an uninterrupted movement. As the locking arrangements pass through their movements of unlocking and locking, they can be felt by the operator. The degree to which they are felt is used as a basis for judging the satisfactory operation of the part of the system undergoing the test.



Interesting detail of a fuel unit and its controls. Note the tubing supports with rubber protections, bonding provisions, or "pigtails," in lower-left and right-hand part of picture. (*Courtesy of Douglas Aircraft.*)

18.20. Completion of Fuel-system Inspection. When the assembly and installation of the entire fuel system is mechanically completed, inspected, and accepted, the system is ready for a proof check for leaks. This leak check is made in the final assembly department.

18.21. Inspection of Oil System. The oil system is inspected and checked in the same manner as the fuel-system installations. The leak check is accomplished in the flight department. On hose connections, it is required that two clamps be used at each end of the hose connection on pressure lines. This is a safety provision, for oil pressures on modern engines range high. The oil system will be described in greater detail in Chap. XXIV, The Power Plant.



Oil-tank installation detail in nacelle. Note the tank-support strops and protecting pads, bonding provisions on tank, rubber hose connections. (*Courtesy of Douglas Aircraft.*)

The fact that oil is not so thin or as readily inflammable as fuel does not relieve inspectors of the duties and responsibilities enumerated in the foregoing sections on fuel-system inspection.

The correct, dependable, and safe functioning of a fuel or an oil system requires that inspectors refer frequently to blueprints, be familiar with specifications and accepted aircraft standards of workmanship, and apply themselves diligently and conscientiously to the inspection assignments.

18.22. General Procedure for Fuel- and Oil-system Inspection. To facilitate inspection, an outline of procedure follows, to be used as a guide by inspectors.

Tubing supports to be checked for the following:

1. General condition and safety of installation.
2. Type of material and size according to blueprint requirements.
3. Compliance with bonding specifications.

Tubing to be checked for the following:

1. Condition (freedom from scratches, nicks, dents).
2. Satisfactory alignment at tubing connections and where tubing passes through supports.
3. Correct size and diameter held at tubing bends.
4. No part of tubing bend within a support.
5. Compliance with lubrication specifications.
6. Correct location and color of tubing identification.
7. Satisfactory and safe clearances between tubing installations and adjacent surfaces and other installations.
8. Installation of provisions preventing tubing from vibrational contact, rubbing, or chafing.
9. Correct material and method used to lace together tubing installations.
10. Protective coating applied on certain lacing material, the correct medium for protection being used and correct methods of application.
11. Installation of bonding provisions, within tolerances of resistance specifications.

Hose connections to be checked for the following:

1. Correct material, diameter, and length according to blueprint requirements.
2. Correct type, material, and size of hose clamps.
3. Tubing ends not touching on inside of hose connection.
4. Correct location of clamps when tubing is beaded.
5. Correct location of clamps on hose material.
6. Compliance of bonding provisions to specifications.
7. Clamps not overtightened.
8. Clamps not cracked at radii of clamp guides.
9. Clamps not bent or twisted.
10. Clamps not damaged by tools.
11. Clamps installed at 90 deg. to hose connection.
12. Double clamps installed on hose connection of pressure lines of oil system.
13. Safety of entire hose-connection installation.

Fuel wobble pumps, valves, etc., to be checked for the following:

1. Correct attachment according to blueprint requirements.
2. Safety of attachment.
3. Alignment of tubing connections and units.
4. Compliance of threaded parts to lubrication specifications.
5. Connections for operation of units according to blueprint requirements.
6. Safety of connections for operation of units.
7. Sufficient and safe clearances when connections made by rods or cables are operated.
8. Correct range of travel as required.
9. Movement of valves smooth and free from binding.
10. Correct locking of fuel valves in the various positions.
11. Identification of units in correct color and location.
12. Condition of units free from damage.
13. Safety of installation and relative connections.

Fuel tanks (before installation) to be checked for the following:

1. Surfaces free from scratches, nicks, dents, etc.
2. Compliance with finish specifications.
3. Fittings not damaged especially where threaded.
4. Openings closed by approved method.
5. Interior of tank clean and free from foreign material.
6. Fuel-quantity gage installed and float operative.
7. Filler neck not damaged.
8. Filler cap fitting correctly.
9. Filler cap showing capacity of tank in stencil.
10. Color on filler cap correct.
11. Bonding provisions installed.
12. Strainers installed.
13. Correct type of strainer in correct location.
14. Strainers identified as to location, as "Main" or "Reserve."
15. Color identification on strainers.
16. Identification plate installed.
17. Identification plate having required inspection stamps.

Fuel tanks (after installation) to be checked for the following:

1. Tank protection pads in correct location.
2. Tank protection pads not damaged.

3. Tank supporting straps in alignment.
4. Tank supporting straps not too tight.
5. Correct type of adjusting provision (turnbuckle).
6. Safety of tank-strap installations.
7. Bonding provisions installed and according to specifications.
8. Sufficient and safe clearances between tank surfaces and tank-bay structure.
9. Filler neck located correctly in wing opening.
10. Filler-neck seal installed and satisfactory.
11. Tubing connections to tank satisfactory and safe.
12. Vent lines connected and installed correctly with sufficient supports and clearances.
13. Fuel overflow or drain line installed.
14. Compliance of threaded connections with lubrication specifications.
15. Identification colors on tubing near tank connections.
16. Safety of tank installation and tubing connections.
17. Strainers coordinating with cutouts in tank-bay covers.
18. Sufficient and safe clearances between strainers and cutouts in tank-bay covers.

System operating controls to be checked for the following:

1. Safety of control installations.
2. Correct directional operation.
3. Correct travel movement.
4. Synchronization of positions of controls and units.
5. Correct adjustment of controls.
6. Identification correct as to color and location of color.
7. Positive locking of flow-control parts in cross-feed and selector fuel valves.
8. Operation of control requiring normal physical effort.
9. Sufficient and safe clearances between control system and adjacent surfaces or installations.
10. Correct lettering identification on control handles.

18.23. Conclusion. The principles developed in this chapter are generally applicable. There may be others to be considered, but these will largely depend on specific design characteristics. Familiarity with the topics discussed will contribute toward thorough and satisfactory inspection of fuel and oil systems.

CHAPTER XIX

THE HYDRAULIC SYSTEM

19.1. Introduction. Because operating pressures in hydraulic systems are steadily being increased, it is important that inspectors inspect and check the hydraulic system of the airplane with close attention to all requirements contained in blueprints, specifications, and special engineering data. Compliance with authorized shop practice and accepted aircraft standards of workmanship is necessary. The safety of the hydraulic system is essential. Inspectors must consult a superior when in doubt about any condition encountered during inspection of the hydraulic system.

19.2. Tubing Supports. The safety of tubing supports depends largely on their installation. The method of attachment must conform to blueprint requirements. Flanges or other types of attaching support should not be distorted by misalignment of attaching holes. Oversize or elongated holes are unsatisfactory. Rivets, screws, or bolts used on support installations are to conform to blueprint requirments and accepted aircraft standards of workmanship. Where stop nuts or nut plates with fiber locks are used, they are inspected for correct penetration of the threaded part of the fastener, in accordance with specifications. Attachments not using stop nuts are inspected for missing lock washers or cotter pins. Bonding methods are checked and inspected for compliance with bonding specifications. Where bonding washers are used, they are closely inspected for broken washers. It must be noted if supports are overtightened or tightened insufficiently. Supports are to seat correctly on surfaces to which they are attached. No part of a support must ride in the radius of another part. Sufficient and safe clearances are required between supports and adjacent surfaces or installations. The safety of tubing-support installations is necessary to the safety of the entire tubing system.

19.3. Tubing and Its Installation. 1. Before tubing is installed, it is inspected closely with respect to its condition.

Its surface must not be scratched, nicked, or dented. The tubing must not be flattened at bends. Correct identification color banding is checked. The condition of flares, sleeve, and nut is noted. The interior of the tubing must be clean and free from any obstruction. Approved factory methods are to be used in checking for internal obstructions. The approved type of tubing covers are removed only in checking the interior of the tubing, which is accomplished just prior to actual installation and connection of the tubing.

2. In the event the contour of a piece of tubing does not comply with installation requirements, it should not be forced into alignment but should be replaced with another piece of tubing. Perfect alignment of hydraulic-tubing connections is essential to the safety of a connection. Should a misaligning connection be forced together, this will constitute a definite threat to the safety of the entire system; such practices are to be avoided. A tight seal for a connection is achieved by the matching of sealing surfaces, not by unreasonable force used in tightening up a connection.

3. Tubing connections must be made with great care. A specified lubricant is applied to the threads of the male connections. Care must be taken to cover the lead threads but to prevent the lubricant from entering the opening of the connection. Specific information on the lubrication of threaded parts in the hydraulic system is contained in authorized factory data. The actual connecting of tubing is also described in the specifications, particularly with reference to the length of the wrenches and the torque to be applied in tightening a connection. Inspectors assigned to hydraulic systems must make every effort to become familiar with these requirements. Tubing connections must not be overtightened, for this will result in damage to the flare on the tubing, causing the connection to leak or break loose altogether. The lubricant applied to the threaded portion of the connection does not contribute to the "sealing" of a connection but only to preventing seizure of threaded parts. The flare seating correctly on its mating surface and held there under proper tension makes the seal. Therefore, a correct connection is the only way to ensure a safe and dependable tubing connection.

4. Where tubing after installation is subject to excessive vibration or where the length of tubing between tubing supports is

considered rather long, provisions for supporting such tubing are installed. These provisions are lacings installed according to authorized specifications and methods. Usually, a plastic strip is used, except that forward of the nacelle firewall, in the power-plant section, oil-tanned leather or cord is used. Specifications call for a protective coating of such lacings.

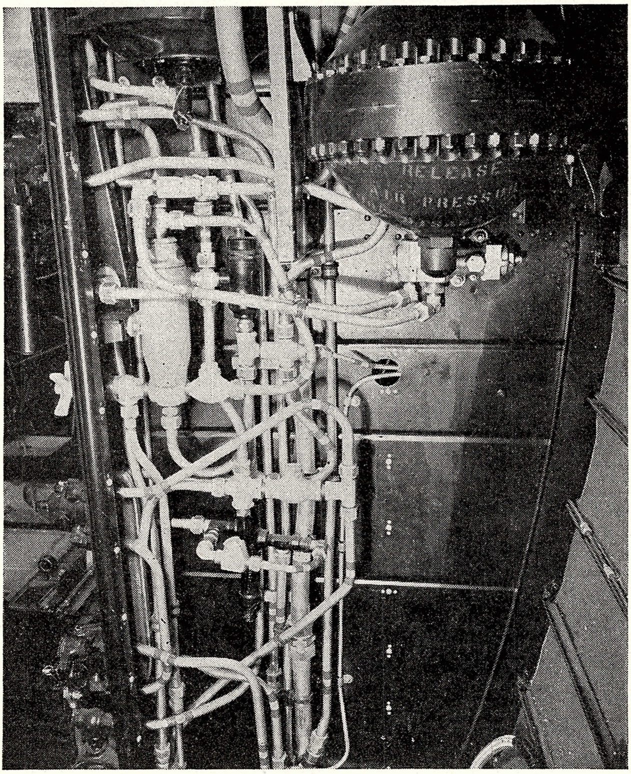
5. Bonding of the tubing is checked for compliance with established specifications.

6. It is necessary to note whether or not the tubing is passing through the support in proper alignment. Angular misalignment is considered unsatisfactory and not in accordance with accepted installation standards.

7. Identification of the tubing is checked for correct location and color banding. Such identification is located on either side of a tubing connection or in any other place that will facilitate the tracing of the tubing in the system. This identification should not be covered, partly or entirely, by any tubing support. If it is so covered, the identification must be removed by approved and authorized methods and reapplied in the most suitable location near the original one.

8. Inspectors are to check carefully for safe clearances between tubing installations and other parts or installations of the airplane. Particular attention should be given the clearances at or near tubing connections, at cutouts through which tubing passes, and near movable installations. When such movable installations are being operated, inspectors are to pay close attention to clearances at tubing installations.

19.4. Flexible Hose Installations. Flexible hose connections are generally used where a motion is expected between two units or where vibration would endanger a metal-tubing connection. Hose connections on hydraulic systems are identified as to material by a color strip (usually white) running lengthwise on the surface of the material. This color strip also will show when a hose connection is twisted by appearing to be curved. Inspectors are to note particularly the alignment of this color strip, for any twist in a flexible hose connection is unsatisfactory and should be corrected. Flexible hose connections are supported as shown on the installation blueprint. It is important to see that a flexible hose connection is not forced over too small a radius in any position. If it is so forced, the purpose of the connection with regard to flexibility is defeated. In addition, such a condition puts an excessive strain on connections and hose material or may restrict the flow as a result of the kinking of the hose material. Therefore, it is most important that such a condition be corrected. Hose connections are checked for the possibility of rubbing or chafing against other units of the airplane. The surface of flexible hose connections is to be clean and free from any dirt or hydraulic fluid.



Hydraulic control panel installed in the airplane. Note the hydraulic storage tank in upper left-hand corner, the hydraulic-pressure accumulator (spherical shape) in upper right-hand corner. (*Courtesy of Douglas Aircraft.*)

19.5. Hydraulic-system Tank Installations. Inspectors are to check hydraulic-tank installations to the blueprint. Compliance in all details is essential to the safety of storage and pressure tanks. Standards of workmanship are noted, and compliance with finish specifications is required. The installation of tanks is inspected and checked for safety of the tank supports. The contours of tanks and their supports are checked for proper coordination. Tanks must be held and supported correctly and securely. If straps are used, they are checked for correct tension and the safety of their attachments and adjusting provisions. Frequent reference to blueprint data is necessary to conduct the inspection satisfactorily; the inspector should not rely only on his memory. Tanks are checked for sufficient and safe clearances at all points. Tanks are closely inspected for damage. Stencils or other means of identification are checked for appearance and correctness. Where provisions are installed for sealing against spilled liquid, inspectors check them for compliance with all requirements contained in blueprint or other authorized specifications. Where possible, inspectors should check the interior of storage or reservoir tanks for cleanliness.

19.6. Tank Connections. Tank connections are closely inspected for safety of connection and correct alignment. All tanks are proof-checked for leaks before delivery to installation departments, and it is therefore essential that no fittings in the tank be loosened to correct a misaligning connection. It is also bad practice to tighten up a fitting to correct a connection, for this may cause the material of the tank fitting to crack. Should a connection of a tank fitting not align properly, the reason must be established and instructions for correction given by a recognized authority. Bonding provisions on tanks are to comply with bonding specifications. Tanks are checked for proper identification and the inspection acceptance stamp.

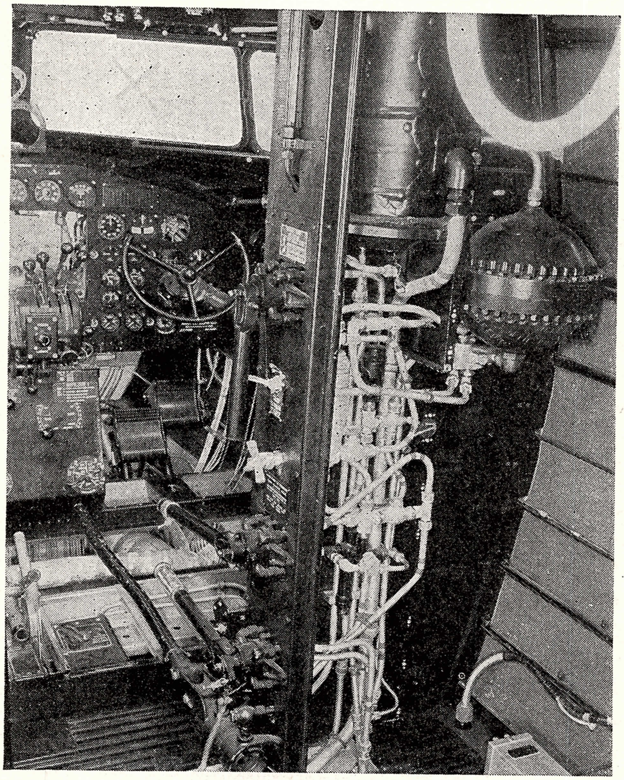
19.7. Operating, or Actuating, Hydraulic Units. Operating units such as actuating cylinders, pressure regulators, and check valves are considered precision parts. They are inspected, checked, and tested before delivery to the installation departments. It is important that they be handled carefully and protected against damage. These units require care and attention during their installation. They must not be forced into position or connections but are to align normally with the parts to which they are to be attached or connected. Safety of installation is important. Inspectors are to inspect them for compliance with the requirements of the blueprint. They are also checked for compliance with specific information issued by factory authority on methods and procedures of installation. It is important that highly polished shafts on hydraulic actuating units should not be damaged and that they should be kept clean and free of dirt, fine metallic dust, and other foreign material. Such material may cling to the highly polished surface of the shaft and be carried during operation into the packing or seal of the cylinder, thus causing it to leak.

19.8. Preparations for Pressure Proof Check. Safe and leakproof hydraulic installations are essential, and to ensure such installations the hydraulic system with all its tubing and units is subjected to a pressure check. Preparatory to this check, specified hydraulic fluid is put into the system according to approved and authorized factory procedure. Hydraulic fluid must be absolutely clean, and therefore the liquid is strained. As the various parts of the system fill with the liquid, a preliminary check is made for gravity leaks. If any are discovered, they are corrected. When this gravity check is completed satisfactorily, the individual systems of the hydraulic system are subjected to the actual pressure leak check.

19.9. Hydraulic-pressure Check. This check is made according to specific and authorized information on methods and procedures. The pressures applied to each system conform strictly to engineering data and specifications. The pressure in each system is held sufficiently long to prove the entire system free of leaks and safe to operate. Inspectors must inspect carefully and diligently the system undergoing the specified pressure check. After being found satisfactory in every detail the system is accepted by inspection and is ready for the actual operation test.

19.10. Preparations for Operation Check. Before operating any part of the hydraulic system, the airplane is carefully checked to determine that the safety of personnel or equipment is not endangered in any way by the operation of the system. The airplane supports and their safety during landing-gear retracting tests are checked. Only after a complete and thorough check and inspection may the system be put in operation. The design of a hydraulic system determines the choice of method and procedure, which are given in the authorized information. Inspectors assigned to witness and check hydraulic-test operations must be familiar with such information.

19.11. First Operation. The first operation of any part of the hydraulic system is carried out at a slow-moving speed. While the unit or units slowly move through the range of travel, inspectors observe closely their action and clearances with other parts of the airplane within the area of the moving units. Doors operating in connection with hydraulic units, such as landing-gear doors, are left disconnected during the first operating tests, so that action and clearances may be observed.



Hydraulic control panel installed showing control handles, hydraulic storage tank, pressure accumulator, and gage showing the hydraulic fluid level in tank. (*Courtesy of Douglas Aircraft.*)

19.12. Position-indicating Provisions. Where provisions are installed that indicate the positions of the hydraulic units in the pilot's cockpit, they are simultaneously checked for correct synchronization between indicated position and actual position of hydraulic unit such as landing-gear or wing-landing-flaps. The correct adjustment of such indicating provisions is important, and inspectors must see that the indications shown correspond to the actual positions of the units affected.

19.13. Locking Mechanisms. Locking mechanisms such as those found on landing gears are checked for proper adjustment and action in the specified positions as landing gear extended or landing gear retracted. Inspectors check these mechanisms according to blueprint or other authorized requirements. Emergency release mechanisms are checked and tested for satisfactory, dependable, and safe operation.

19.14. Landing-gear Covers or Doors. Doors hooked up to operate automatically, such as those on landing-gear openings, are checked and inspected when closed for proper fit, and alignment of surface contours with adjacent surfaces and for correct preload adjustments. Particular attention is given the sealing provisions and the specified clearances between landing-gear wheels and tires and the inside surface of the door. The inspectors check the safety and operation of all door installations with reference to blueprint requirements and accepted standards of workmanship.

19.15. Time Consumed for a Cycle. Where specifications call for this, inspectors check the time required by certain units to complete a half or full cycle of movement. The time consumed is to be within authorized time limits and tolerances before being accepted.

19.16. Conclusion. The task of inspecting hydraulic systems and their installation and equipment is a responsible one. Inspectors must refer to blueprint requirements, specifications, and authorized factory information regarding methods and procedures. Standards of workmanship are to be satisfactory and the safety of the entire hydraulic system must be unquestionable before inspectors accept the system.

CHAPTER XX

THE OXYGEN SYSTEM

20.1. Introduction. The oxygen system of an airplane serves a vital purpose. It supplies the crew or passengers with needed oxygen during higher altitude flights. The oxygen is stored under pressure and supplied from steel tanks which are connected in series but are individually controlled as to output by a manually operated valve equipped with a pressure gage. The released oxygen is piped to individual outlets suitably located for use by personnel or passengers. To these outlets are attached by flexible hoses the sets used by the individuals. Each outlet is provided with a valve manually operated for turning on or off the supply or controlling the amount required. If storage or supply tanks are inaccessible when the airplane is in flight, the valves on these tanks must be opened before take-off. Flow- and pressure-indicating gages are either located at the supply tanks or are incorporated in the individual outlet regulators.

20.2. Lubrication Specifications. *No lubrication may be used on threaded parts unless specifically authorized;* this is of the greatest importance to the safety of this system. The specifications should state the type and kind of lubricant to be used and describe in detail the method and procedure of its application. Inspectors must be familiar with such special requirements and are to check to see that no lubricant enters the interior of the tubing system.

20.3. General Procedure for Inspection. For inspection of an oxygen system and its installation the following may be used by inspectors as a guide:

1. It must be ascertained that supply tanks are full of the specified amount of oxygen. This is checked according to approved and authorized factory procedure. Records of inspection are to be made out as prescribed.

2. Provisions for installing oxygen-supply tanks are checked for compliance with blueprint requirements. The installations are inspected for satisfactory condition and safety.

3. Tanks installed are closely inspected for the safety of tank-holding provisions. Adjustment of straps is checked for looseness or too great a tension. Cotter pins and safety-wire installations are checked for acceptable workmanship. Straps are inspected for fit and proper alignment. They should not be installed at an angular setting but are to be at 90 deg. to the tank and coordinate as to contour fit. Padding installed on the base or side supports of tanks is inspected for condition and compliance with the specifications. Tanks must be held firmly in position and are to have sufficient and safe clearances at all points. Safety of tank installations is essential.

4. Tubing is checked and inspected for compliance with all blueprint requirements with respect to condition and with aircraft standards of workmanship. Tubing is to be free of flattened bends, kinks, and scratches; and connections are checked for proper location and alignment. The surface of the tubing should be clean, and connections are to be neat in appearance. Clamps, supports, and lacings on tubing installations are inspected and checked for the location, attachment, sizes, and material given on the blueprint or contained in specifications. Required and sufficient clearances with other parts or installations are checked for, and inspectors must make certain of the security and safety of the piping installations. Identification of tubing is checked for location, correct color, and neatness of appearance. Compliance with electric bonding specifications is required.

20.4. Regulators and Their Installation. Pressure and supply regulators are inspected for security of installation. Inspectors note the physical effort required to operate them and make sure that their operation is satisfactory and their safety established. These units are checked for sufficient clearances at all points and for the possibility of vibrational contact with other parts or installations.

20.5. Rubber Tubing. Rubber tubing on individual sets is closely inspected for signs of deterioration. If the condition of such tubing is open to doubt, new tubing must be installed.

20.6. Internal Obstructions or Leaks. The safe operation of the oxygen system must be ensured. All tubing in this system is pressure tested according to specified pressures and procedure prior to installation in the airplane. After installation the tubing installations are tested for internal obstructions or leaky connections according to authorized and approved factory procedure. It is important that defective tubing be replaced with *new and tested* tubing only.

20.7. Conclusion. The safety of personnel and equipment depends to a great extent on the correct, dependable, and safe functioning of the oxygen system. Inspectors checking the system and its installation must keep in mind at all times this important fact.

CHAPTER XXI

THE HEATING AND VENTILATING SYSTEM

21.1. Introduction. Heating and ventilating provisions are installed in airplanes for the comfort of their occupants. Physical comfort increases the efficiency of the operating crew of the airplane and thus contributes to the safety of the occupants and to the airplane itself. The heating system consists fundamentally of a unit furnishing heat which warms incoming air. The warm, clean air is distributed in air ducts to outlets located in various compartments of the airplane. The supply of warm air is controllable to ensure uniform heat and may be regulated with respect to degree of heat.

Heating systems are usually designed for use as ventilating systems during conditions when heat is not desired.

21.2. Visual Inspection. The heating unit is inspected visually for condition and for safety of installation. Clearances are important and are checked closely. Attachment provisions of the heating unit are inspected for alignment with attaching surfaces, and tubing connections to the unit are subject to careful inspection. The identification plate located on the heating unit is checked for the inspection acceptance stamp. This acceptance stamp indicates that the unit has passed all required inspections and tests. The condition and safety of the heating-unit drain plug is inspected and checked closely.

21.3. Water-supply Tank and Its Installation. The water-supply tank installation is inspected for compliance with blueprint requirements. The condition of the tank is inspected visually for any damage. Tank supports and provisions for holding the tank are checked for correctness and fit, proper tension and safety. Tubing to tank connections is to be tight, in proper alignment, and not twisted or damaged by badly fitting wrenches. The tank filler cap is checked for ease in removal and for security of the lock after closing. Usually the capacity of the tank is shown on the outer surface of the tank filler cap.

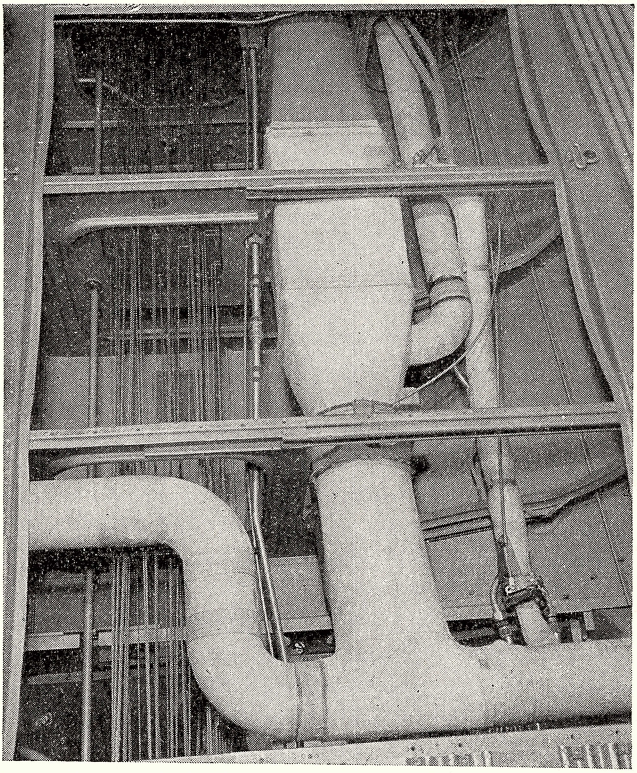
The inspector should become thoroughly familiar with blueprint requirements and specifications on tank installation. The entire tank installation must comply with accepted standards of workmanship, and its safety must be established before acceptance by inspectors.

21.4. Heating Radiator Unit. The air-heating radiator unit is important. It must be closely inspected for compliance with blueprint installation requirements. The core is checked for damage and for cleanliness of its passages. Insulation provisions on the body of the radiator are to conform to all requirements and should be free of damage. Specifications on the insulation material used and its installation must be noted. Provisions to control the air flow are to conform to blueprint requirements, and their operation is checked for ease of operation and direction of movement. Sealing provisions in the vicinity of such regulating provisions or the radiator itself require close inspection to see that condition and installation are satisfactory. Inspectors should check the radiator unit and its connections and installation for compliance with all requirements and must be assured of its safety before accepting the unit.

21.5. Safety Valve. One of the most important parts of the entire system is the relief, or safety, blow valve. Its correct functioning and installation are vital to the safety of the system. The valve itself is tested and carefully adjusted to the manufacturer's specifications, and it should under no condition be tampered with. Its installation is inspected for safety and compliance with all requirements as shown on the blueprint. The mechanism to permit the steam to escape in case of blowoff is of great importance; inspectors must check this mechanism in reference to blueprint requirements.

21.6. System Control Valves. Control valves and their installations are inspected for compliance with blueprint requirements and for ease of operation and direction of movement. Instruction plates located near valves are checked for correct information and appearance.

21.7. Steam-tubing Installations. Steam-tubing installations are inspected very closely. Safety and fit of tubing supports are noted and bonding provisions checked to specifications. Clearances between tubing and other parts of the airplane are checked at all points and must be sufficient and safe. The alignment of tubing connections and their safety are observed. Identification of tubing is to correspond to specifications with respect to location, color, and neatness. Provisions installed on tubing to reduce heat loss are to be visually inspected for appearance and evidence of damage. Specifications affecting such installations are to be complied with, and the installation of this material is to conform to blueprint requirements.



Interesting study of a heating- and ventilating-system installation. Note the insulation material, control on steam tube (small tube in lower right-hand corner), air control valve partially hidden by flooring support. Also of interest are the control cables passing through fairleads. (*Courtesy of Douglas Aircraft.*)

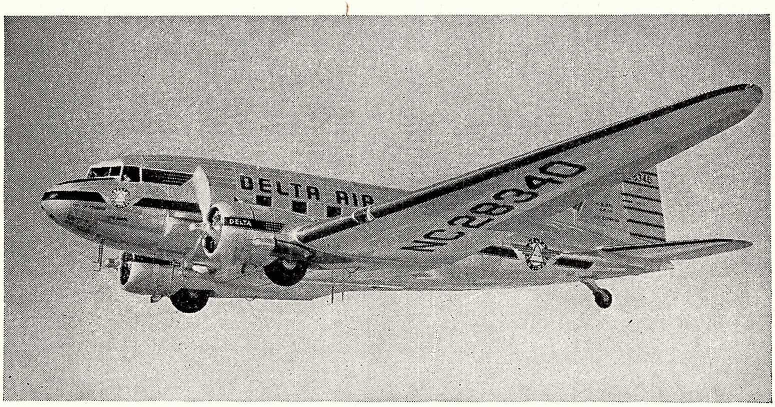
21.8. Heating-duct Installations. Heating-duct installations are inspected for compliance with blueprint requirements. Visual inspection is made of the ducts for nicks, dents, scratches, or flattened surfaces. Particular attention is given the duct connections. These should seal and fit snugly, for leaks will lower the efficiency of the system. Attaching clamps on ducts are checked for correct fit, alignment, and proper size and should not be overtightened. Where the blueprint calls for provisions to prevent heat loss, these are to be inspected and checked according to all requirements. Duct intake and outlet provisions are inspected for safety.

21.9. Conclusion. The inspection of a heating and ventilating system requires careful attention to details, reference to the blueprint, familiarity with authorized finish specifications, and knowledge of accepted aircraft standards of workmanship. The correct and safe functioning of such systems will contribute to the reputation of the men who inspected them.

CHAPTER XXII

THE DE-ICER SYSTEM

22.1. Introduction. De-icing provisions installed on surfaces of airplanes are designed to increase the safety of airplanes. Ice forming on surfaces of the airplane, such as wings and vertical and horizontal stabilizers, is dangerous for two reasons: (1) Ice accumulation on the leading edges changes the characteristics of the airfoil. (2) Such formation adds considerable weight. Through experience, it has been found that not only surfaces having the shape of an airfoil should be protected against ice but also other parts on the outside of airplanes such as radio masts and compass loops. A separate de-icer system is now used to protect engine propellers. Engine carburetors are protected against ice by directing a stream of hot air into their intake opening.



Douglas Airliner in flight. Note the de-icer installation on leading edges of wing and horizontal stabilizer. (*Courtesy of Douglas Aircraft.*)

22.2. De-icer Shoes. De-icer shoes are installed on certain parts of the airplane to prevent ice formation. A de-icer shoe consists of a certain number of rubber tubes which are supported by suitable material. The rubber tubes are inflated with air under a certain design pressure and according to a predetermined rotation and time limit. When ice forms, the expansion of the inflated rubber tubes cracks the ice and the loosened ice is blown off by the air stream.

22.3. Operation of a De-icer System. Inspectors must understand the operation and functioning of a de-icer system. Details of design or construction of units are obtainable within the factory and will not be discussed here. However, the following will describe the operation of a de-icer system.

Air required to inflate the rubber tubes in the de-icer shoes is obtained from the air discharge of the vacuum pump. The only objection to obtaining the air from this source of supply is that a considerable amount of oil is contained in the air. It is not desirable for the oil to enter the rubber tubes for obvious reasons. To prevent the oil from reaching the tubes an oil separator is used.

The air after going through the oil separator passes through a check valve and enters the main, or common, supply line. A check valve is needed at this point to prevent loss of air in case the supplying vacuum pump fails to function. It also prevents the air from returning through the vacuum pump into the suction side of the instruments.

The air travels through the main line to a distributor valve. This valve is designed so that if the de-icer system is not in operation the air is routed to the outside of the airplane. If the system is in operation, the supply of air is once more routed through a second oil-separator unit. Upon leaving the second oil separator the air re-enters the distributor valve and is then distributed into the various de-icer shoes. The distributor valve is of the rotating type and is rotated every few seconds; during this time, one complete cycle of shoe inflation occurs. Rotation of the valve is accomplished by an electric motor which is part of the distributor-valve assembly.

The distributor valve has a certain number of outlet ports through which the air is supplied to a set of de-icer shoes. As the valve rotates, each part is supplied with air under pressure for a certain amount of time. At the same time the other parts are discharging air from the shoes. The exhausted air from these parts is routed into a single outlet port from which the air is expelled to the outside of the airplane. The outlet of the tubing connecting this part with the outside of the airplane is located in a low-pressure area on the plane and is therefore actually sucked out.

The distributor valve has another port through which air is drained from the inflated shoes when the system is shut off after operation.

22.4. Operation Control. The operation of the system is governed by a single control located in the cockpit and connected to the control shaft of the distributor valve. The control on the distributor-valve shaft is connected to the electric switch on the motor in such a manner that the motor starts automatically when the distributor-valve control is turned.

22.5. Pressure-indicating Gage. To know the amount of pressure with which air is delivered to the system a pressure gage is installed in the pilot's cockpit. The pressure gage is calibrated to certain pounds pressure per square inch and is connected to the second oil separator. By knowing the specific pressure required to operate the system the pilot can determine if the system operates correctly by watching the pressure as shown on the gage.

22.6. Draining Tubing. It is important that tubing be installed without any low spots, or "traps," in which moisture might collect. If such an installation is not possible, provisions are made to drain the low points, or traps.

22.7. General Procedure for Inspection. To check the de-icer system for correct operation and functioning a test connection is installed between the check valves and the distributor valve. Air is supplied by a special test pump, and the system can be observed and checked for correct operation as called for in engineering information.

Points to watch in inspecting a de-icer system and its installations are as follows:

1. Tubing supports and attachments are inspected for conditions such as damaged bents or misalignment. Their safety is important.

2. The appearance of the tubing is checked. Its surfaces are inspected for damage such as nicks, dents, scratches, and kinked or flattened portions.

3. The alignment of tubing connections is checked. Tubing should not enter connections at any angle, and the specified lubricant on threaded parts is a requirement.

4. Clearances are noted between the tubing installation and other parts of the airplane.

5. Tubing is checked for provisions eliminating vibration, such as lacing installations. These are to conform to authorized specifications and methods of installation.

6. Identification of tubing should correspond in location, color, and application to specifications and is to present a neat appearance.

7. Bonding provisions are inspected and checked for compliance with all bonding specifications.

8. Particular attention must be given the connections that join metal tubing to the rubber hose connections of the de-icer shoes. Their correct and safe installation is essential.

Operating units such as vacuum pumps, check valves, distributor valve, and control units are inspected for correct and safe installation. These are checked according to blueprint requirements and accepted standards of workmanship. Clearances are essential between these units and adjoining surfaces or installations.

Controls are inspected for compliance with blueprint requirements. Clearances and safety of installation are checked. The controls are operated through the entire range of movement, and particular attention is given the direction and setting of required travel. Controls should operate freely without binding at any point of movement, and the indicated position of the control in the pilot's cockpit must correspond to the actual position of the control on the distributor-valve shaft. While controls are going through their movement, inspectors should see that all pulleys rotate, and are properly safetied and that cables are in proper and satisfactory alignment. Safety for cable connections and the condition of turnbuckles are of importance. Fairleads are checked for condition, cable alignment, and safety of installations. No cable connection must enter pulleys or rest against fairleads. Correct operation and safety of the controls in the de-icer system are essential.

Installation of de-icer shoes is inspected for compliance with all blueprint requirements, and special attention is given authorized factory specifications, methods, and procedures. The shoes are visually inspected for fit, tautness, and safety of attachments. The surface of the shoes is closely checked for evidence of damage or defects in material. The alignment of the shoes with underlying surfaces is noted and any unsatisfactory condition corrected.

Provisions for draining low points, or line traps, are checked for functioning. Drains must not be obstructed; when found satisfactory, they are closed and safetied as shown on blueprint.

During the actual test operation of the de-icer system, inspectors observe the sequence of inflation of de-icer shoes for compliance with blueprint requirements. The pressure as indicated on the gage in the pilot's cockpit is checked for compliance with technical requirements. The pressure indicated is to be within established limits and tolerances.

22.8. Conclusion. It is very important that the de-icer system function properly, dependably, and to the end for which it is designed. This is essential to the safety of the personnel and equipment of the airplane while in flight.

CHAPTER XXIII

THE FIRE-EXTINGUISHER SYSTEM

23.1. Introduction. In an airplane, fire may break out at any time despite the most careful and well-designed precautionary measures. Therefore, all possible equipment is provided and installed to extinguish a fire at its very start. This equipment protects the airplane not only while on the ground but also while in flight.

23.2. Types of Fire-extinguisher Equipment. Fire-extinguisher equipment is of three distinct types.

1. Hand-operated equipment.
2. Mechanically operated equipment.
3. Automatically operated equipment.

23.3. Hand-operated Equipment. Hand-operated equipment consists of small fire extinguishers which in case of fire are operated by hand just like a hand pump. They are installed in the airplane in locations that permit access while the plane is on the ground or in flight. They are used by the plane personnel in cases where fire has broken out in crew or passenger quarters.

23.4. Inspection of Hand-operated Equipment. Inspectors should note the condition of the fire seal wire that is attached to the operating handle. This wire when unbroken indicates that the unit is fully charged and ready for instant use. If this wire is found broken, inspectors should have the unit replaced with one having an unbroken seal wire. The unit with the broken seal wire should be returned to the proper department for checking and resealing. It is important for installation provisions to conform to blueprint requirements and for them to be in a condition to hold the extinguishers safely and properly in place. Inspectors should note the manner of release of the holding mechanism if the extinguisher unit is removed rapidly. This is important in case of actual fire. Surfaces behind and adjacent to a fire-extinguisher installation are to be painted (red) according to the correct dimensions of the color field as well as the specified color. Inspectors are to observe any condition that may cause injury to a person removing the extinguisher from its installation. If such conditions exist, authorized corrections must be made. No airplane must be accepted by inspection for flight if all required fire extinguishers are not installed or if a broken seal wire is on any of the units. The safety of the operating personnel or passengers must not be endangered at any time.

23.5. Mechanically Operated Equipment. This equipment provides fire protection for sections of the airplane where the fire hazard is greatest. These are the power-plant sections and the section aft of the nacelle firewalls on the inside of the engine nacelle.

In this equipment, carbon dioxide gas is the means used to extinguish a fire. It is supplied from a loaded steel cylinder and is distributed through tubing to the sections mentioned previously.

23.6. Details of Equipment. This fire-extinguisher system consists of the following:

1. One or more steel cylinders containing carbon dioxide gas stored under a certain pressure per square inch.
2. The necessary release valve or valves.
3. The controls required to operate the release valves.
4. Piping or tubing distributing the gas upon its release to the various sections of the airplane, as designed and called for on blueprints.

23.7. Controls. The mechanically operated equipment is controlled from the pilot's cockpit. Pull handles are provided which actuate the release valves on the storage cylinders. When the handle is pulled, a seal on the tank release is broken and the gas rushes into the system. Controls in the cockpit are arranged so that the left-engine or right-engine system can be operated independently from one another. A selector valve is provided for the selection of the system that must be put into operation.

23.8. Safety Device. Since the gas in the steel cylinder is held under high pressure, it is readily seen that if exposed to high temperatures it will expand. This would constitute a dangerous condition were it not for the safety blowoff valve which is built into the neck of the cylinder, or tank, in the form of a diaphragm. The design of the system provides that upon unusual expansion of the gas the diaphragm will rupture and discharge to the outside of the airplane through tubing installed for this purpose. The outside opening of this tubing is covered with a material that breaks easily. This material is painted red, and the cover is readily seen by visual observation. Inspectors check this red-colored material for evidence of having been broken. This would indicate that the supply of carbon dioxide had escaped and that the tank is empty, which requires replacement of the empty tank. This inspection is very important, for the safety of the personnel of the airplane depends on the proper amount of carbon dioxide gas available in case of an emergency.

23.9. Weighing the Carbon Dioxide Supply Tank. It is very important that any carbon dioxide tank be weighed before installation. The weight of the tank must correspond to the weight data as given in specifications. Should the weight be less than the one given in the specifications, this is taken as an indication that the tank is not as full of gas as required for acceptance for installation. Such a tank is not to be installed in an airplane.

23.10. Supply-tank Installation. Inspectors are to check the installation of carbon dioxide tanks, or cylinders, according to the blueprint requirements. Safety of installation is important, and because the cylinders are heavy the installation of their supports is closely inspected. Sufficient clearances are essential, particularly in the vicinity of the tank or cylinder operating valves. cleanliness near the tank installation is essential, for loose parts or material may lodge in the operating levers of the valve mechanism and thus definitely endanger its operation.

23.11. System Controls. Control installations are subject to careful inspection. They are checked for compliance with all requirements in blueprint or authorized specifications. Proper, dependable, and safe functioning of controls is vital. Controls are checked for clearances or possible interference, safety of pulley installations, and control-cable adjustments. The alignment of cables in pulleys is noted. Inspectors must check for loose parts or other foreign material that may lodge in pulleys or cling to the cables. Operating handles are checked for proper installation, and identifications must correspond with blueprint requirements. It is important that inspectors check the correct installation of controls in respect to direction and movement of travel. It must be established that controls are not crossed up.

Only after controls have been found correct in all details and safe should they be accepted.

23.12. Tubing-system Installations. Tubing installations are to conform to requirements as shown on the blueprint. During inspection of tubing installations, inspectors should check the tubing for scratches, nicks, dents, or flat spots or for kinks at radius bends. Alignment in supports and connections is important. Lacings for prevention of excessive vibration of tubing are to conform to specifications and accepted standards of workmanship. The size and fit of supporting clamps are observed. Also, all clearances are checked between tubing installations and other parts of the airplane. Lubrication specifications for threaded parts are to be complied with; inspectors should check for evidence of a lubricant on such parts. Electric bonding specifications are checked for compliance with approved bonding methods and readings. Identification of tubing is to conform to specifications with respect to location, color, and application. A neat and clean appearance is required.

23.13. Special Tubing in Fire-hazard Areas. Particular attention must be given the tubing installations in sections where fire hazards exist. These sections are part of the powerplant installation (accessory and carburetor section) and just aft of the nacelle firewall on the inside of the nacelle. Inspectors are to check with their blueprints the particular sections in which a special type of tubing is installed as part of the fire-extinguisher system. This tubing is of the perforated type. The carbon dioxide gas will escape through the numerous small holes when the system is operated. Inspectors should check to see that none of these holes is obstructed. Should the holes be stopped up, their purpose will be defeated, and the effectiveness of the system will be dangerously affected. The safety of the tubing installation is the responsibility of the inspectors.

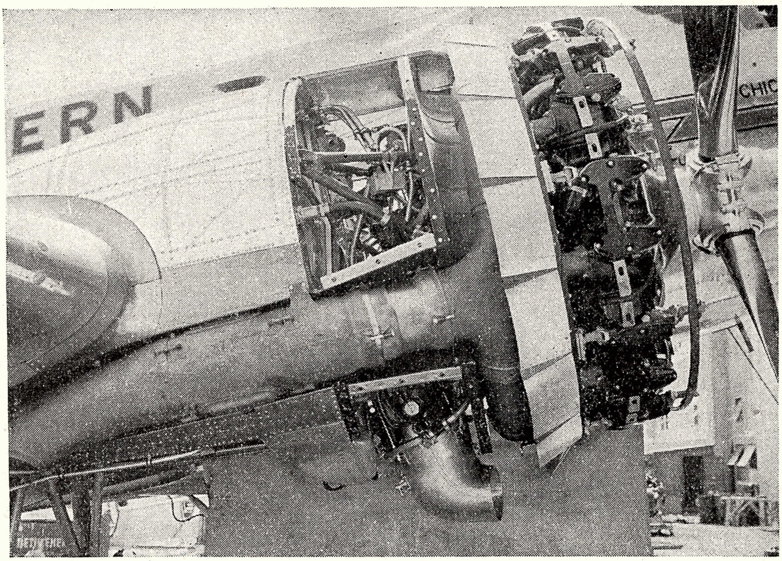
23.14. Automatically Operated Equipment. The principle involved in automatically operated equipment is that of heat affecting a thermoreacting unit. The seal on the heads or outlets of these units is made of a material of special composition. Should a fire start in the section where such a unit is installed, heat will be generated and the temperature will increase until it reaches the critical heat to which the seal material in the unit reacts. The seal begins to soften and eventually breaks, releasing the medium used to extinguish a fire. Inspectors check the location and installation of these units with their blueprints. The condition of the sealing device is observed closely; it must be perfect before it is accepted.

23.15. Conclusion. Inspectors checking the installation and operation of a fire-extinguisher system should refer to all authorized information contained in blueprints and specifications and should be guided by shop practice and accepted standards of workmanship. Fire starting in an airplane during flight is a most serious matter, and yet this emergency may be overcome successfully by the correct and timely functioning of fire-extinguisher equipment. The importance of the fire-extinguisher system to the safety of the airplane and its occupants is self-evident. Inspectors can ensure this safety by the proper and careful inspection of the system.

CHAPTER XXIV

THE POWER PLANT

24.1. Introduction. The power plant is given a great number of careful and thorough inspections, from its very beginning to the completed assembly. The following discussion is not intended to replace in any way authorized technical information furnished by the manufacturer of the numerous units or that issued by the factory. Inspectors are to use such information in combination with established methods and procedures of the factory. What follows in this chapter is only a general discussion of the inspection of the power plant. It is intended to be used as a guide, not as an authority.



Power-plant installation on a Douglas Model DC-3 Airliner. (*Courtesy of Douglas Aircraft.*)

24.2. Receiving Engine at Aircraft Factory. When an engine is received at the factory, it is checked in with the shipping papers. The inspector assigned to the receiving department inspects visually the box in which the engine is shipped. He notes any possible damage sustained during shipment.

24.3. Receiving Engine in Engine Department. The engine department then receives the engine, which is still in its box together with the necessary shipping papers. In the presence of an inspector, the engine box is opened. When factory authority requires the presence of a representative of the customer's inspection office, the engine box is not opened unless the representative of this office is present or authorization has been received permitting the opening of the box without the representative being present.

24.4. Opening of Box. The lid of the engine box is then removed and the engine uncovered. Accessories individually packed and stored within the engine box are uncovered and laid out for inspection. It is the duty of the inspector to check the engine to the information given on the shipping papers, such as type and serial number of the engine. Careful inspection is given the engine for evidence of damage. Should any damage have occurred during shipment the inspector should follow factory authorized procedure regarding necessary steps to be taken in reporting such damage.

24.5. Engine Accessories. If the engine has been found satisfactory and all information given on the shipping papers is in agreement with the identification of the engine, the inspector next turns his attention to the accessories. These are given a detailed and close physical inspection, and parts having a serial number, type, or model identification are checked to the corresponding shipping papers. After all such parts or units have been found satisfactory with respect to physical condition and if their identifications agree with the shipping papers, the inspector will clear the papers according to established procedure.

24.6. Draining the Oil. After engine and accessories have been found satisfactory by inspection, the engine is further prepared for the next operations. It is necessary to drain all internal oil from exhaust ports and cylinders, preferably while the engine is still in its base support within the lower half of the engine shipping box. This operation is accomplished according to established and authorized procedure. After the oil has been drained, the engine is removed from its box. Caution is necessary during removal to prevent damage to parts of the engine.

24.7. Inspection of Areas Previously Inaccessible. After the engine is removed, the inspector checks for possible damage in areas on the engine that were inaccessible while the engine was in its shipping box.

24.8. Blower, or Supercharger, Section. After oil-draining operations are completed, the cover is removed from the blower, or supercharger, section for inspection of the interior of the blower chamber. Inspectors check the impeller closely and carefully for any possible damage to its blades; they also make sure that no loose parts such as nuts or cotter pins or pieces of safety wire or other foreign material are present in the blower section. When this inspection is completed, a cover is reinstalled over the opening of the blower chamber and secured. Usually this cover is stamped by the inspector accepting the blower section, indicating thus its satisfactory condition.

24.9. Recording Special Items. After the engine is installed in its temporary engine stand, it is good practice to check and record identifications of the various units such as ignition shielding, or harness, magnetos, starters, carburetor, pumps, and any others that may so be recorded. Identification of such parts will not be so easy after completion of the engine installation, for they will then be less accessible.

24.10. Driving Provisions for Accessories. Before any driven accessories are installed, inspectors should check the driving provisions for freeness of operation and physical condition. This check is made by turning the free ends with the fingers.

24.11. Installation Gaskets. Gaskets used on installations of accessories are checked and inspected for fit and condition. It is important that inspectors make certain that no *shipping* gaskets are used on installation where specific installation gaskets are furnished. Some shipping gaskets do not have holes cut as required; installation of such gaskets would endanger the function of the unit or system involved.

24.12. Attaching Surfaces of Accessories. Attaching bases of accessories and their mating surfaces on the engine are inspected for cleanliness. This is essential to the tight and effective sealing of the installation.

24.13. Inspection of Accessories during Installation. The installation of accessories requires careful work and attention. Driving extensions are to line up and fit correctly and are not to be forced into connection. Should the installation of an accessory drive connection prove difficult, the cause must be ascertained and corrected. The bolts or nuts by which the unit is attached are to be tightened in proper rotation, and the unit is to be supported while attachment is accomplished. Tension on nuts or bolts is to be applied gradually and evenly; otherwise, undue distortion of flanges will result, causing cracking or breaking of attaching flanges. It is important that threaded parts be installed carefully. If they are started incorrectly or are too tight in their threads, they should not be forced together. Instead, the unsatisfactory condition must be corrected, and inspectors noting such conditions should cooperate in eliminating them. Methods of locking or installing safety wire on a connection are checked by the inspector for compliance with all requirements. Inspectors inspecting and checking accessory installations on engines should check every detail for compliance with authorized information given out by the factory. Should any doubt exist as to any condition encountered, the inspector is to consult his immediate superior. When the installation of accessories is completed and accepted by inspection, the necessary entries are made in the inspection records and the engine is released for installation on the actual engine mount.

24.14. Engine Mount. The engine mount consists of a number of units that are installed and inspected before it can receive the engine. Owing to differences in procedure demanded by differences in design only a general discussion of inspection procedure follows.

24.15. Inspecting the Engine Mount. The engine mount itself is checked for the magnetic inspection stamp and the production acceptance stamp. It is checked visually for any damaged condition in the protective finish and for general alignment of its parts. While the motor mount is in its assembly jig, inspectors note the fit of the engine mount in relation to its jig attaching and holding surfaces.

24.16. Dynamic Rubber Suspensions. The installation of dynamic rubber suspension provisions is important. Inspectors should watch the procedure of installation for compliance with specifications. Attention is called to the requirement which calls for certain tension tolerances on the installation of bolts in these provisions. Tension check wrenches are furnished, and inspectors must note and record the satisfactory installation readings on these bolts.

24.17. Clearances. Where any parts or units are subject to movement or travel, inspectors check for sufficient and safe clearances at all points. The safety of such installations is essential.

24.18. Movable Units. Inspectors are to inspect and check closely the condition, installation, clearances, and alignment of spacers, bushings, bearings, etc. These parts are also checked for compliance with the blueprint and with accepted standards of workmanship. A movable unit must not bind in any position of its design travel. Compliance with lubrication specifications is required. Safety provisions as called for on the blueprint are checked for condition or omission. It is important that no installation be accomplished by using force necessitated by an unsatisfactory mechanical condition; instead, the condition should be corrected.

24.19. Final Inspection of Engine-mount Unit. When the engine mount and all its required installations are completed, it is at this stage given a final inspection. Inspectors should check it according to blueprint requirements, finish and process information, and accepted standards of workmanship. Close attention is given alignment of units, safety of installations, sufficient clearances, proper torque readings on bolted installations, and lubrication provisions (installed and accessible). Parts and their installations must be lubricated as called for in specifications, condition of parts must be satisfactory, finishes must be as required, no locking or safety provisions should be omitted or poorly installed, and the entire engine-mount assembly and its installations must be safe and must comply with all accepted aircraft standards of workmanship. When all points are found satisfactory and acceptable, inspectors release the engine mount and its units for installation of the engine.

24.20. Inspection of Engine during Installation on Mount. During the installation of the engine on the engine mount, no force is to be used to effect alignment of installation points. Authorized and approved factory procedures and methods are to be followed during installation. Specifications on the torque to be used on bolt installations are to be followed in detail; inspectors should watch these operations. A record of bolt-installation torque readings must be made by the inspector checking the torque.

24.21. Inspection of Engine after Installation. After the installation of the engine on its mount, other installations are made such as those of the motor diaphragm, collector ring, cowl-flap mechanism, tubing, and engine controls. Inspectors generally check these installations after their completion and prior to installation on the airplane. However, units such as the carburetor and the engine cowl-flap operating mechanism are checked before completion, for inspection afterward would be extremely difficult.

24.22. Cowl-flap Mechanism and Its Installation. The cowl-flap mechanism is inspected and checked according to all blueprint requirements. It is important that inspectors check closely condition, fit, alignment, and manner of installation of bolts and taper pins on the actuating levers. Ease of operation through the entire operation movement is to be noted, sufficient and safe clearances are observed, and the safety of the entire mechanism is closely checked before accepting and releasing it for cover up. When covers are installed, inspectors check them for safety, alignment, and fit. Where installations or parts pass through, they are closely checked and inspected for sufficient and safe clearances in all possible positions.

24.23. Inspection of Carburetor before Installation. The carburetor, one of the most important units of the engine, is carefully inspected before installation on the engine. When it is found satisfactory in all respects, the inspector will witness the removal of the sealed cover on the engine and after a second thorough inspection of the engine blower chamber the carburetor is installed. It is very important that during installation no loose parts be dropped into the blower chamber. Inspectors are to note the condition and fit of the gasket installed between the carburetor body and the engine. Safety of attachment is closely checked; where safety wire is installed, its material is to agree with blueprint requirements. The safety of the carburetor installation is important. To ensure this, after inspection the throttle is usually put in the closed position and sealed in this position by approved factory methods; thus, loose parts or foreign material cannot fall into the carburetor. This sealing provision usually can be removed only by an authorized member of the inspection department. As soon as carburetor is installed and the throttle sealed, an approved type of temporary cover is installed on the carburetor opening.

24.24. Inspection of Exhaust System. Collector-ring and exhaust-system installations are checked for compliance with all blueprint requirements. Of importance are proper clearances, alignment at connections and supports, installation of sealing provisions, and safety of attachments. Inspectors are to note the type and material of locking nuts, cotter pins, etc. Where the blueprint calls for nut-plate installations, inspectors check for compliance with specifications stating the limits of temperature at which certain types of nut plate are used.

24.25. Tubing Installations of Power Plant. Tubing installations are to be checked for nicks, dents, scratches, or flattened tubing supports; clamps and lacings are checked for installation according to blueprint requirements and for safety. Clearances are observed and bonding requirements inspected for compliance with resistance-reading limits and tolerances. Alignment of tubing connections and tubing supports is to be noted. Identification on tubing must correspond with specifications. All ends of tubing that is to be connected later are to be kept covered.

24.26. Hose Connections. Hose connections are carefully inspected for compliance with blueprint requirements. Inspectors are to check for correctness of hose material which is identified by one or two red stripes or one white and one red stripe running longitudinally or in a spiral around the body of the hose material. The type of clamps used and their position on the hose connection are important. The clamps are checked for proper alignment and tightness. When the ends of metal tubing are beaded, inspectors must be sure that the clamps are located correctly in relation to the beads and that the ends of the metal tubing do not touch each other within the hose connection. Clamps are inspected closely for possible cracks in the radii of the clamp guide due to overtightening. Clamps should not be damaged by the use of pliers or other incorrect mechanical means; special wrenches should always be used in tightening hose clamps. Attention is called to the requirement of double hose-clamp installations on the pressure side of the engine oil system. Hose connections are checked for compliance with bonding specifications and approved methods. The alignment of hose connections is important to the durability of the hose and its freedom from future leaks; inspectors should therefore check the alignment. Hose connections are provided where vibration is expected; sufficient and safe clearances should exist near such connections. Specifications on the use of lubricants to facilitate hose installations should always be followed; it is the duty of inspectors to check for any unauthorized methods used to install hose material on tubing.

24.27. Oil-cooler Installation. Oil-cooler installation requires careful and detailed inspection for compliance with all blueprint information. The importance of dependable, correct, and safe functioning of this unit is self-evident. Inspectors should note the condition of the cooling unit itself. Air passages in the core are to be clean, unobstructed, and undamaged. The body of the unit should be undamaged and its shape undistorted in any way. Alignment of the oil cooler with its supporting provisions should be checked, and the fit is important. Methods of protecting the unit, such as pads or neoprene straps, are inspected for installation and correct position on the unit. Tension and safety of supporting provisions are checked for compliance with accepted standards.

24.28. Fittings and Tubing Connections of Oil-cooler Unit. Fittings and tubing connections are inspected for condition, alignment, lubrication, and tightness. Fittings and connections should not be damaged by badly fitting wrenches.

24.29. Oil-temperature Control. Provisions for oil-temperature control are to be checked for compliance with blueprint requirements and accepted standards of workmanship, alignment of connections, freeness of operation, direction of movement, proper travel range, and safety of installation.

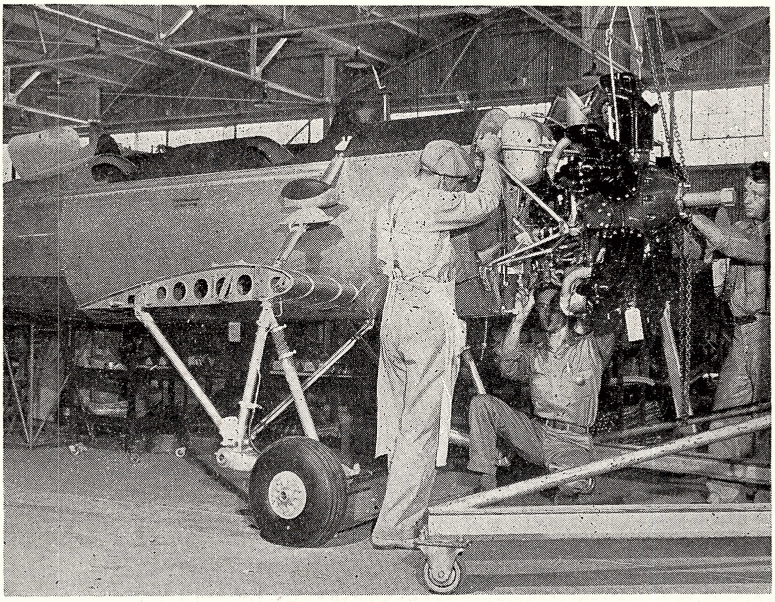
24.30. Engine Controls. Engine controls and their installation are inspected for compliance with all technical requirements. Pulleys and their installation are checked for condition, alignment, clearances, and safety. Cables are inspected for evidence of unsatisfactory condition and for alignment, lubrication, identification color, proper tension, and safety of turnbuckles. It is important to note clearances between cables and adjacent surfaces or parts of the engine section. Where cables pass through fairleads, inspectors are to observe the type of the cutouts and the clearance between cable and hole in the fairleads.

Cutouts in fairleads are to be such as to prevent the cable from working its way out once it is installed. Reference to the blueprint is required in checking the details of fairlead cutouts.

24.31. Inspection of Electrical Installations of Power Plant. Electrical installations and equipment are carefully checked and inspected for compliance with all blueprint requirements, specifications, and accepted standards of workmanship. Particular attention is given terminals and their connections. Connection plugs having a number of slip-joint connections are inspected for appearance, condition, and safety. The terminals are to be undamaged, undistorted, and free of dirt or any other foreign material. The installation of flexible electric conduits is checked for compliance with requirements. Inspectors should see that flexible conduits are not forced over too short a radius, that specifications are followed in respect to protection under supporting clamps, and that installations are safe. Blueprint and other factory information is to be used by inspectors as their authority in inspecting electrical installations and equipment of the power plant.

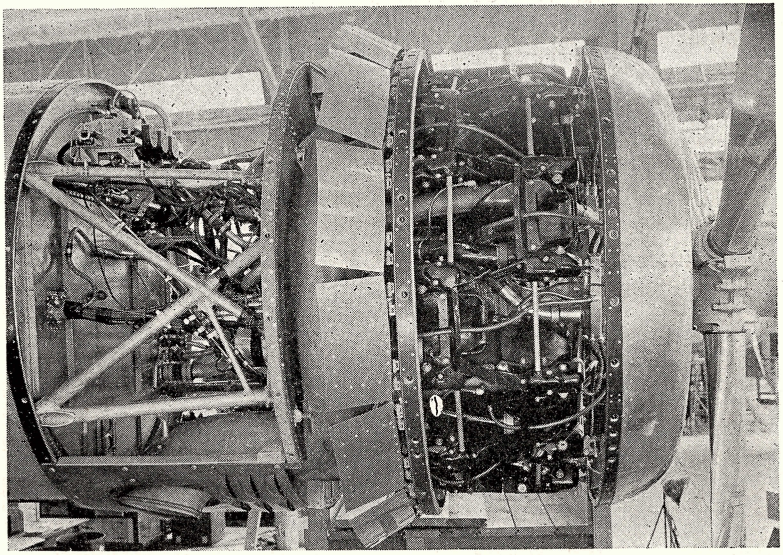
24.32. Inspection of Power Plant before Installation on Airplane. A careful and rigid inspection of the entire power plant and its components, with their installations, is imperative, for the continuous, dependable, and proper functioning of this unit is essential to the safety of the airplane and its personnel. When it has been found satisfactory in all respects, it is released for installation on the airplane.

24.33. Inspection of Airplane Firewall before Power-plant Installation. Before a power plant is installed on the airplane, inspectors check the area of the nacelle firewall to which the power plant will be attached. It is important to check carefully any provisions to which the power plant will be attached, such as threaded trunnions or holes in which attaching bolts are installed. Should threaded trunnions be used, they are checked for condition and cleanliness of threads. Holes provided for bolt installations are inspected for cleanliness of interior surfaces and correct diameter; they should not be out of round or otherwise damaged. Installations on the forward side of the firewall are checked for compliance with blueprint requirements and other specifications. The safety of such installations is of primary importance. All tubing to be connected to the power plant must be checked for correct routing, the information given on the blueprint being used as reference. The condition of the firewall itself is checked for general condition. Particular attention is given the nacelle-skin trim, or edge, extending past the surface of the nacelle firewall; this check is important, for the dimension of this trim, or edge, is calculated to provide specified clearance between the antidrag ring or cowling installation and the nacelle skin of its forward end. When the firewall with all its installations and the line routing are found satisfactory, the power plant is installed.



Installation of complete power plant on a Ryan trainer plane. (*Courtesy of Ryan Aeronautical Co.*)

24.34. Power-plant Installation on Airplane. During installation of the power plant, inspectors observe the alignment of engine-mount attaching points and nacelle attachment provisions. The bolts used to install a power plant to the nacelle are special bolts. They are lubricated as called for in specifications and tightened with torque-indicating wrenches as specified. Inspectors watch the amount shown on the indicators before the bolt installation is safety wired. Bonding provisions are called for on engine-mount attachments and are checked for correct type, material, and installation. Should difficulties be encountered during the installation of a power plant, the causes must be ascertained and corrected; no force is to be used in making such an installation. After the power plant is installed, the various systems are connected as required.



Complete power-plant installation. Note the engine cowl-flap installation. (*Courtesy of Douglas Aircraft.*)

24.35. Conclusion. Inspectors checking a completed power-plant installation must inspect carefully and in detail all safety provisions, clearances, attachments, and supports as shown on blueprints or required by specifications, authorized shop practices, and accepted aircraft standards of workmanship. Familiarity with blueprint information specifications and approved standards, methods, and procedures is essential to a trouble-free and safe power-plant installation.